SCIENTIFIC AMERICAN SUPPLEMENT. No. 1543

Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1905, by Munn & Co.

Scientific American, established 1845.
Scientific American Supplement, Vol. LX., No. 1543.

NEW YORK, JULY 29, 1905.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.


SINGLE-DECK, 16-PASSENGER TWO-CYLINDER WOLSELEY MOTOR OMNIBUS SUPPLIED TO GREAT WESTERN RAILROAD. THE ROOF IS UTILIZED FOR CARRIAGE OF BAGGAGE.


TWO-CYLINDER SINGLE DECK 14-BRAKE-HORSE-POWER MAUDSLAY MOTOR OMNIBUS SUPPLIED TO GREAT WESTERN RAILROAD. CLIMBING HILL 2 MILES IN LENGTH AND HAVING A GRADIENT OF 1 IN 7 AT 5 MILES PER HOUR WITH 12 PASSENGERS.

ENGLISH MOTOR OMNIBUSES FOR CITY AND COUNTRY USE.

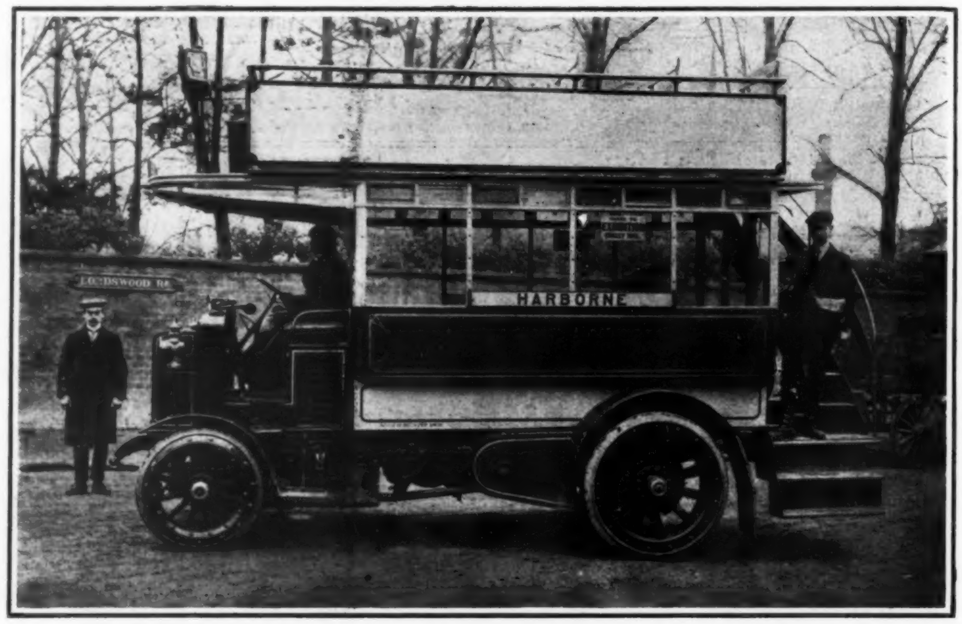
## ENGLISH MOTOR OMNIBUSES FOR CITY AND COUNTRY USE.

By Our English Correspondent.

A few weeks ago we drew attention in the columns of the Scientific American to the rapid development that is now in progress in England, and more especially in London, of the motor-powered omnibus as opposed to the extension of electric street surface railroads. Few cities have been more reluctant to possess a rapid system of interurban transit, as is supplied by electric cars, than London, and it is only within the past three years that the London County Council, the governing municipal authority, has converted the horse-drawn tram cars on the southern side of the River Thames to electrically propelled cars. In the northern area, which is populated by over 2,000,000 people, electrification has hardly progressed, though negotiations are now under way for the electrification of the whole of this system. But already the project is being attended with several hitches on the part of the various borough councils through which the track extends. During the past few months the motor-propelled omnibus has made great headway, and it is rapidly being realized that in this new vehicle the street electric trolley car has its most formidable rival. The authorities demur against being hastily committed to a huge expenditure for an elaborate electrical conversion scheme, when there is evidence that the motor omnibus gives every indication of becoming the paramount transit vehicle. Consequently a halt in electric tramway development has already been called.

Several advantages of the motor-propelled vehicle contribute to this deadlock. This vehicle has long since passed through the transitory experimental stage. For some years past the leading motor manufacturers have devoted their energies to the perfection of this type of car and are now consequently able to place upon the streets an efficient, reliable vehicle capable of fulfilling all the requirements of rapid traffic. The Shoreditch Borough Council in particular opposed the London County Council's electrification scheme. Owing to the dense and congested nature of the street traffic in this district, the breaking up of the roadways for the installation of the electric track and its equipment would entail complete dislocation of the traffic and a heavy financial loss to the business houses in the district. The expense again would be abnormally heavy, the lowest estimate for electrification being $125,000 per mile of single track completed and equipped with six cars per mile. In view of the fact, however, that previous estimates have proved so remarkably incorrect it is anticipated that the ultimate cost would be far heavier. As an alternative the authorities of this borough suggest that the existing track be retained and that gasoline-propelled cars, lighter than the present electric ones (which weigh approximately 20 tons) be obtained. One English motor firm, the Wolseley Motor Car Company, has already designed for foreign service tram cars of this nature, and they have proved in every respect equal in efficiency and reliability to the electric vehicle, without any of the inherent disadvantages of the latter. A description of the Wolseley gasoline-electric car will be found in Supplement No. 1520. The superiority of the gasoline-propelled tramcar lies especially in the fact that each vehicle is a separate unit. Should a breakdown occur upon any car, it is only that one vehicle which is affected, and it can be towed by another vehicle to the depot for overhauling without disorganizing the whole service, whereas with the electric system a failure of one car, or the current, causes a complete cessation of the traffic throughout the whole system, until the fault has been repaired.

The first town in Great Britain to conclusively demonstrate the possibilities of the motor-propelled omnibus was Torquay, in Devonshire, some few years ago. At first only two vehicles were procured as an experiment. The Clarkson system was adopted, in which steam fired by oil fuel is the motive power. Owing to the hilly nature of the district it was a severe test for the vehicle, but the large fleet of omnibuses now in operation have proved highly reliable and efficient. The average speed is greater than could be maintained by an electric trolley car, and the average cost per passenger mile has equaled 0.125 cent per mile. A dividend of 7½ per cent was recently declared upon the year's operation. The total receipts were $11,450 from fares. Of this amount 10 per cent was allowed for depreciation, $2,000 for maintenance, and $1,375 for rubber tires. Experience has shown that the durability of the latter is much greater than is popularly believed, the life of the tires on the rear wheels in these stages being 10,000 miles, and the front tires 15,000 miles. In Birmingham the success has been more marked, the profit obtained, after providing for all management and working charges, and after writing off depreciation to the extent of 20 per cent per annum on the cars, and charging all repairs and renewals to revenue account, being 6 cents per mile. In this city, it must be pointed out, there is an excellent electric trolley service, and in face of the severe competition thus offered the profit obtained is in every sense highly satisfactory. The company maintaining a motor omnibus service in the south of England resorts, Hastings and St. Leonards, has declared a dividend of 15 per cent for the past year.



28-HORSE-POWER FOUR-CYLINDER DOUBLE-DECK WOLSELEY MOTOR OMNIBUS.

In London the competition offered by the Council tramways renders the successful issue of the motor omnibus a far more difficult matter. During the past year the street railroads south of the Thames carried over their thirty-odd street miles of track 126,255,280 passengers, and 10,931,396 car miles were run. The total receipts were $2,741,480 and, after defraying all expenses, a total net surplus of $37,272 resulted. The cost of operation averaged 14.98 cents per mile, whereas, with the horse-drawn system, the cost averaged 20.46 cents per mile, showing an advantage in favor of the electric system of 5.48 cents. If in London the system of a uniform fare of say five cents were adopted, as in the United States, the profits would probably be greater, but the fares in the English metropolis are arranged on a sliding scale, the short distance cheap fares being the most prolific. The average fare per passenger was 1.94 cents. Of the total number of passengers carried 35.97 per cent paid 1 cent fare, 47.10 per cent paid 2 cents, 9.12 per cent paid 3 cents, 5.01 per cent paid 4 cents, 1.18 per cent paid 5 cents, and 1.62 per cent paid 6 cents. From this it will be seen that the 2-cent fare was the most lucrative, and was followed very closely by the 1-cent fare.

With regard to the motor omnibus traffic, these vehicles compared very favorably with the electric trolley cars in every respect, though as they have not been in operation for a year, comparative statistics are difficult to obtain, more especially as the results are being carefully maintained a secret of the companies interested in the exploitation of the self-propelled traffic. When ranged beside the horse-drawn omnibus, however, the advantage is far and away in favor of the motor vehicle. There are at present over 2,500 horse-drawn omnibuses plying in the city. These represent at an average cost of $650 each, a total invested sum of $1,625,000. Each vehicle requires 12 horses to work it, each costing $200. The harness represents another $100, and the requisite stabling accommodation $3,000. There is thus a capital charge attendant to one horse-omnibus of $6,150.

Messrs. Tilling have installed a self-propelled vehicle service between Peckham, a point 5¼ miles from the city in the southern suburbs. For a distance of 4 miles they run side by side with the electric trolley cars. For the 4-mile distance the former charge 4 cents, and the motor vehicle 6 cents for the 5¼ miles. The maximum carrying capacity of the electric car is 70 passengers, while that of the self-propelled coach is 34 passengers. Yet the latter shows a greater profit per day and also does the longer journey in approximately the same time in which the former completes the shorter distance.

The cost of the motor omnibus is $4,300 and the garage for the same represents a further outlay of $1,000, an advantage of $615 over the horse-drawn vehicle. The cost of the street surface railroad averaged $125,000 to complete track and equip it with six cars per mile. The total cost on this basis for the round journey of eight miles represents an outlay of $1,000,000. To provide a similar service of self-propelled omnibuses entails an outlay on the round trip of 10½ miles of $330,750 including garage accommodation.

The comparisons between the maintenance of the motor and horse-drawn services over the same distance are as follows:

| | Motor omnibus | Horse omnibus |
|---|---|---|
| Average receipts per week.. | $210.00 | $61.50 |
| Miles covered per day....... | 115 | 70 |
| Profit per week (average).. | $33.65 | $5.00 |
| Time occupied on journey.. | 38 min. | 47 min. |

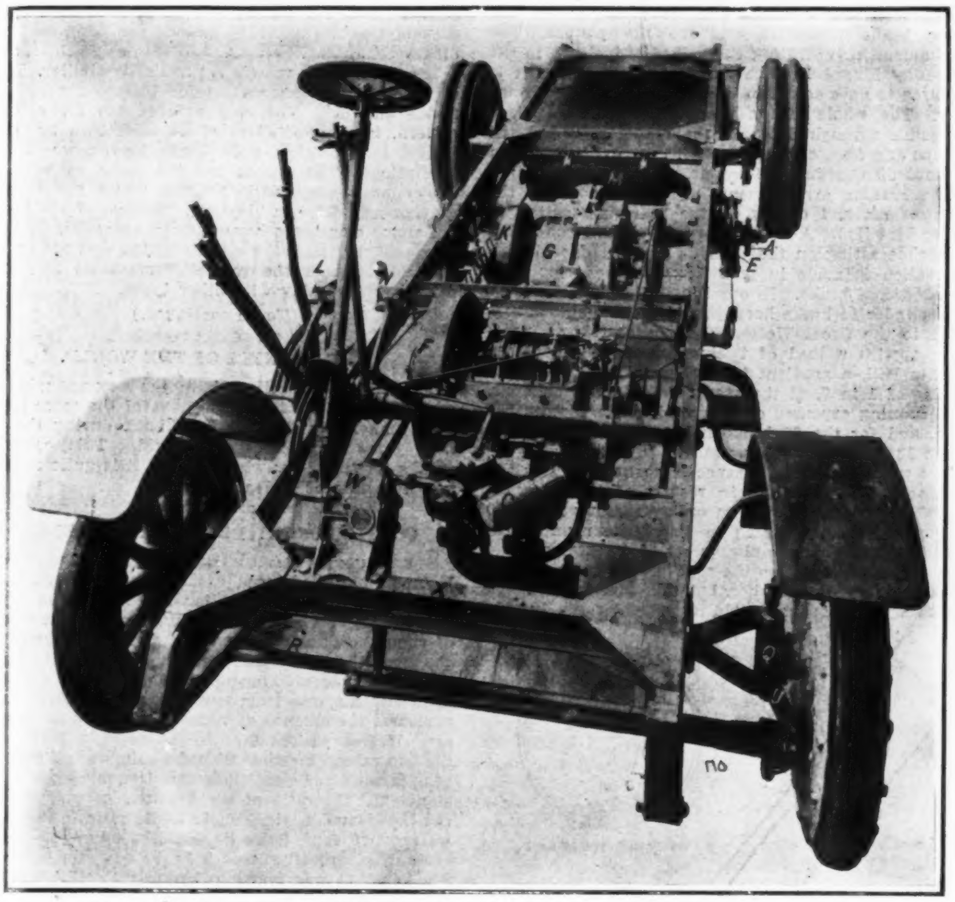
The above results, which are based upon three months' operation, show an overwhelming advantage of the motor vehicle over the horse-drawn system.

FOUR-CYLINDER 20-HORSE-POWER MILNES-DAIMLER MOTOR OMNIBUS FOR LONDON SERVICE. SEATS 34 PASSENGERS.

ENGLISH MOTOR OMNIBUSES FOR CITY AND COUNTRY USE.

During the coming year the various companies interested in the omnibus traffic of London have made arrangements to supplant the obsolete horse vehicles by the more expeditious motor-propelled cars. Within the next two years, according to present progress, there will be over 2,000 motor coaches engaged in the traffic. It has already been found that one automobile will do the work of two horse-drawn stages, and this fact, coupled with the greater mileage that can be covered by one motor coach in a given time, combined with a corresponding decrease in the expenditure and increase in receipts, has supplied a great impetus to the movement. The omnibuses being adopted are of two types—the single-deck, in which passenger accommodation is provided within, with the roof utilized for the carriage of baggage and freight, and the double-deck type, in which passengers are carried inside and out. There are about a dozen manufacturers engaged in the construction and supply of these vehicles, and in the course of this article are described the leading types, together with the financial results of their operation.

All the types, with one exception, are propelled by gasoline motors. The single exception is the Chelmsford vehicle, wherein the motive power is steam generated by oil fuel. Nearly all the various types are in use in London, the numerous companies having selected the description of vehicle which is most coincident with their especial requirements.



PLAN VIEW OF CHASSIS OF 28-HORSE-POWER DOUBLE-DECK WOLSELEY MOTOR STAGE.

A. Driving sprocket on countershaft. B. Transmission brake. C. Carbureter. E. Brake on countershaft. F. Flywheel of four-cylinder horizontal motor. G. Transmission. K. Clutch. L. Brake pedal. M. Muffler. N. Clutch pedal. P. Steering rod. Q. Steering knuckle. R. Tie rod of steering arms. S. Reynold silent chain from motor to transmission. U. Steering arm. W. Worm gear steering device. X. Front axle.

The first of the new London gasoline omnibuses acquired by Messrs. Tilling & Co. for their regular service, and the London Motor Omnibus Company for their 5½-mile route, is the Daimler type, which has also been used for some time past in many provincial centers and by the various railroad companies. These omnibuses range in horse-power from 20-horse-power double-deck to 18-horse-power and 17-horse-power single-deck. The former is the type adopted for the service between the suburb of Peckham and Oxford Street in the metropolis, while 36 similar vehicles have been supplied to the Great Western Railroad. These vehicles are built by the Canstatt Daimler Company, of Germany, whose touring automobiles have long been before the public.

The general appearance of this vehicle may be gathered from the accompanying illustration. It is primarily intended to provide accommodation for thirty-six passengers—sixteen inside, eighteen outside, and two beside the driver. As, however, the London licensing authorities will not permit passengers to sit beside the driver, so that he may not be disturbed from his duties by conversation or other extraneous attractions, the carrying capacity of the vehicle is reduced to thirty-four passengers. The vehicle is roomy and well lighted and ventilated. The overall length is 24 feet by 7 feet 2 inches, with a height to the hand-rail of 12 feet 6 inches. The wheel base is 11 feet 3 inches with a mean track of 4 feet 11½ inches. The rear wheels are shod with twin tires, the object of which is both to distribute the weight, and to reduce, if not entirely overcome, side slipping when traveling upon greasy road surfaces, such as wet asphalt or wood pavings. The tires are of 40-inch diameter by 4-inch tread. The front wheels are somewhat smaller in diameter, being only 32 inches, with solid tires of the same tread as those on the rear wheels.

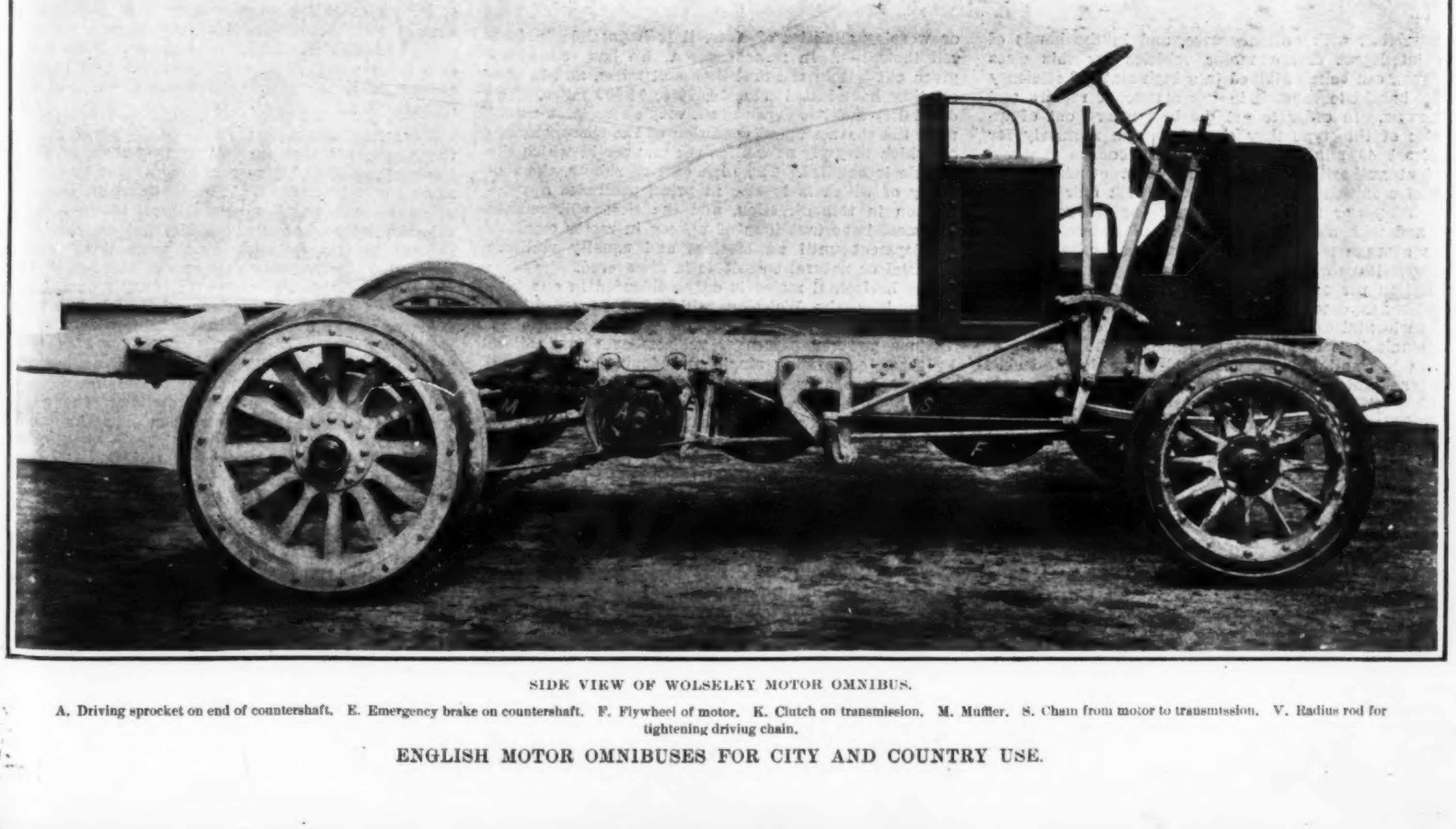
The chassis weighs complete 3 tons with a four-cylinder vertical engine. The omnibus shown in our illustration is fitted with a 20-horse-power motor developing 22 horse-power at the normal speed of 800 revolutions per minute, and capable of a maximum speed of 1,000 revolutions, at which 25 brake horse-power is developed. The cylinders have a bore of 105 millimeters and 130-millimeter stroke.

The frame of the chassis is built up of strong steel girders of channel cross section. Rigidity is insured by several cross members. It is carried on the wheel axles by semi-elliptical springs with the back ends of those to the rear wheels connected together by a transverse spring passing beneath. The motor and change-speed gear are carried upon an underframe strongly and firmly riveted to the main frame. Two wooden beams fixed rigidly to the back axle serve as radius rods. They are hinged to special brackets at the front ends, and stiffened with steel plates. These members not only serve to relieve the springs of all strains set up by the driving mechanism, but they are sufficiently flexible to absorb sudden shocks. As they lie almost horizontally, the driving wheels have free up-and-down movement.

Fixed direct to these wooden radius rods, which constitute a feature of the Milnes-Daimler vehicles, is a casing containing the countershaft which drives the rear wheels, and the compensating gear is introduced between them. Each half of the countershaft carries a spur-gear pinion outside the casing, and these pinions mesh with internal gear rings bolted to the road wheels.

There is another unusual feature in the transmission gear of these vehicles, and that is the mounting of the differential gear on the rear end of the longitudinal driving, or propeller shaft. This is a departure from the orthodox practice of mounting it on the countershaft itself. Each differential member has a pair of bevel wheels placed between it and one-half of the countershaft. The result of this arrangement is that the differential gear not only runs at a higher speed than would otherwise be the case, but the liability of strains is appreciably reduced.

The flywheel and clutch cone are constructed with fan blades, so that in revolving they induce air through



SIDE VIEW OF WOLSELEY MOTOR OMNIBUS.

A. Driving sprocket on end of countershaft. E. Emergency brake on countershaft. F. Flywheel of motor. K. Clutch on transmission. M. Muffler. S. Chain from motor to transmission. V. Radius rod for tightening driving chain.

ENGLISH MOTOR OMNIBUSES FOR CITY AND COUNTRY USE.

the honeycomb radiator and thereby assist the cooling of the water. The transmission gear is of the sliding type, giving four speeds forward—2½, 4½, 6, and 12 miles per hour respectively—and reverse. It is operated by a hand lever working in a quadrant conveniently placed near the driver. The steering gear is of the usual worm and segment irreversible type, adjustable so as to take up all wear.

Owing to the difficulties attending driving in crowded thoroughfares, and the frequent acceleration and retardation required, as well as sudden stops, special attention has been devoted to the braking facilities. One powerful brake is mounted on the front and second-motion shaft controlled by the same pedal that manipulates the clutch. But the pressure on the clutch pedal does not apply the brake at first, since partial depression simply disengages the clutch, and the engine runs free without driving the first-motion shaft, so that the chassis can still be moved if desired. If required the pedal can be locked in this position when the vehicle is at rest. The brake drum upon which the metal shoes apply is water-cooled, a system of circulating being adopted. Two other brakes act upon the rear driving wheels, being mounted on the ends of the countershaft just inside the spur wheels. These are also applied by a foot pedal. A third brake acts upon the tires of the road wheels, for emergency purposes, and is applied through a side lever.

Gasoline fuel is primarily intended to be used, reservoirs for a supply of 16 gallons being carried. The fuel consumption approximates one gallon per hour. Should gasoline be difficult to procure, however, heavier oil may be used, there being a special vaporizer for this purpose. In this case it is only necessary to start the engine with gasoline, after which the heavier oil fuel (kerosene) may be employed.

In omnibus operation this type of self-propelled coach has proved highly successful. Experience has shown that with ordinary care, and in the hands of an intelligent driver, motor vehicles for this class of work can be maintained in a high state of efficiency with but little expense in the matter of repairs and renewals. In order to get the best return out of vehicles of this type they should be run regularly for at least 40 miles per day. At Eastbourne the municipal authorities have a large fleet of single-deck vehicles of this make in use fitted with four-cylinder, 16-horse-power and 18-horse-power engines respectively, and with a passenger capacity of sixteen persons. The average receipts are 27 cents per mile, with a daily mileage of 76 miles. The average gasoline consumption per mile represents 5.7 cents, and the total working expenses, including depreciation, up-keep, and all incidental expenditure, amount to 20 cents. Owing to single-deck omnibuses being used, the margin of profit is small in comparison with the double-decked variety, which will carry twice as many passengers with a trifling increase in the running cost.

Twelve months' operation with these vehicles at Hastings shows a total distance of 55,000 miles covered. Receipts work out at 29 cents per mile, while the total expenditure per mile is 23 cents, leaving a profit of 6 cents per mile. On the past year's working the profit was sufficient to enable a dividend of 15 per cent to be paid.

One of the latest manufacturers to participate in this motor omnibus movement is the Maudslay Motor Company, of Coventry. The Great Western Railroad, one of the pioneers of motor traction for passenger traffic, has adopted this vehicle on one of their services where hill-climbing capacity is an important factor. The Maudslay vehicle is made in three standard types—single-deck, 14 brake horse-power, two-cylinder; 20 brake horse-power, three-cylinder, and 30 brake horse-power, four-cylinder double deckers. The principle in each vehicle is practically the same. The frame is of steel with gear-driven water-circulating pump, sliding gear of the Panhard type giving four speeds forward and one reverse with single lever control. In the 30-horse-power, four-cylinder vehicle the cylinders are of 5-inch bore by 3½ inches stroke, developing maximum power at 950 revolutions per minute. In this engine both inlet and exhaust valves, following the Maudslay practice with large engines, are mechanically operated and are placed in the cylinder heads immediately above the pistons. The mechanism for operating the valves is inclosed in the Maudslay hinged lay shaft casing which, when it is required to have access to the valves, is simply thrown over. The whole of the bearings to the motor are accessible through doors in the crank case, and the pistons and connecting rods can be removed therefrom without dismantling the engine.

The braking arrangements are ample both on the countershaft and drums on the rear axle acting in either direction. A third emergency brake, consisting of a shoe acting on the tires, is also fitted, while an innovation is made in providing the conductor with an additional brake. In our illustration the Maudslay two-cylinder 14 brake horse-power motor omnibus supplied to the Great Western Railroad is shown negotiating, with a load of twelve passengers, the steep Birdlip Hill, a gradient two miles in length with an incline of 1 in 7, at the speed of five miles an hour. The running expenses of this vehicle are 8 cents per mile, and for the 30 brake horse-power four-cylinder coach 12 cents per omnibus mile.

The greatest item of expense in connection with the motor-propelled coach is in respect of the tires. A set of four tires involves an outlay ranging from 120 dollars upward, according to size. The running expenses of the tires are always set at 4 cents per mile run. In some instances the cost is a trifle lower, and in others somewhat higher, but this sum is the mean average. As it is impossible to guarantee the durable or wearing qualities of tires, it is impossible to foretell their life. In some cases a tire has completely given out within the first thousand miles, and in others they have lasted from 10,000 to 15,000 miles. The durability and life depend to a very appreciable extent upon the character and condition of the thoroughfares on which they ply as well as the manner in which the vehicle is handled. The high cost of rubber, the tendency of which is to rise in price, precludes any reduction in this direction, and the tires will remain the most important item of upkeep in motor omnibus development until an efficient and equally resilient artificial or natural substitute is discovered.

The horizontal motor is only evidenced in one type of omnibus, the Wolseley, which has proved highly efficient in the products of this manufacturing firm. Various powered passenger vehicles are standardized by them, comprising single and double deckers, and open chars-a-bancs, as well as the application of the internal-combustion motor to street surface railroad cars. The construction is carried out on the well-known Wolseley lines throughout, the design only varying with the horse-power and carrying-load requirements. The single-deck vehicle is designed to meet the demand of railroad companies where both passengers and freight have to be carried, especially in rural districts. Accommodation is provided for twenty-two passengers—sixteen inside and six in front with the driver. The roof is continued over the driver's head, thereby giving large area for baggage.

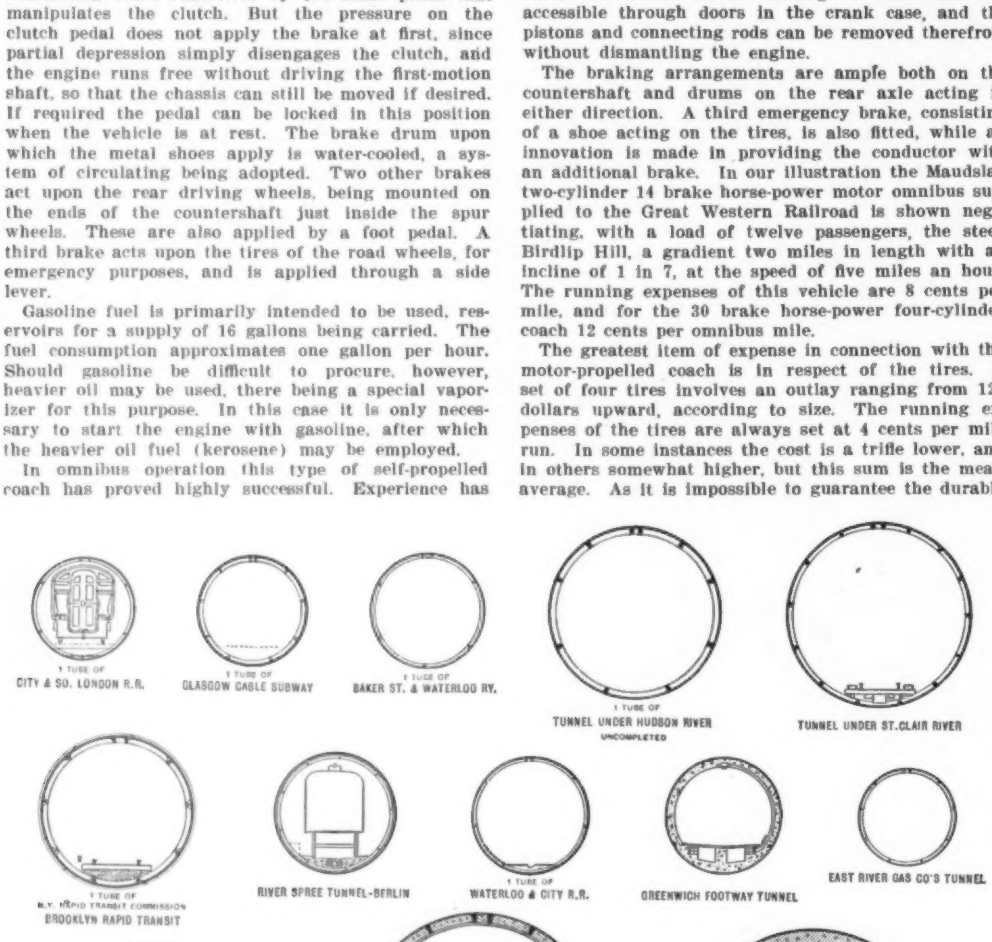
The chassis is 12 feet in length with a track of 6 feet 2 inches. The frame is of pressed steel. One advantage attending the employment of the horizontal engine is the availability of greater space for passenger accommodation than is possible with vertical motors. The two-cylinder engine generally employed in this vehicle is of 6-inch bore by 7-inch stroke, developing 20 brake horse-power at 600 revolutions. No governor is fitted, the engine being controlled by hand and foot throttles. The power from the engine is transmitted to the gearing by a heavy roller chain. The gear is of the sliding type, giving four speeds of 2½, 5, 8, and 13 miles respectively forward, and one reverse speed of 5 miles an hour, all controlled from one lever. From the gear box the drive is transmitted to the driving wheels by side roller chains. The gasoline tank has capacity for 12 gallons, and the fuel consumption averages 1¼ gallons per hour under ordinary conditions.

The double-deck vehicle is practically similar. There is passenger accommodation for thirty-six passengers inside and out. The engine is of the four-cylinder pattern, having cylinders of 4½-inch bore by 6-inch stroke, and developing 24 brake horse-power at 750 revolutions. The speeds are the same as with the two-cylinder single-deck vehicle, while the type of gearing and drive is identical. Several of the Wolseley motor omnibuses have been in operation for some time past, but statistics as to running cost are not yet available, though the various users state they compare very favorably with other types.

(To be continued.)

## THE TUNNELS OF THE WORLD.

The editor has collected, in the accompanying engraving, a series of cross sections of the more important tunnels which have been built during the last fifty years throughout the world. This collection speaks for itself, for which reason it is quite unnecessary to comment at length upon it.




## CONTEMPORARY ELECTRICAL SCIENCE.*

Absorption of Radium Emanation by Liquids.—R. Hoffman has discovered a method of estimating the amount of radium emanation contained in a liquid, based upon Traubenberg's observation that the amount of emanation absorbed depends, as in the case of any gas, upon the temperature and the nature of the liquid. He proceeds by shaking up the liquid twice in succession with air free from emanation. In both cases he measures the amount of radio-activity acquired by the air. If Henry's constant is the same in both cases, the two values, together with the volumes of liquid and gas, furnish sufficient data for determining the constant—i.e., the ratio of the densities of emanation in the liquid and in air. He finds the ratio to be 0.23 in water at 20 deg. Some liquids, like toluol, absorb the emanation greedily, especially at low temperatures. The constant was found to be 66.69 at —79 deg., and 11.76 for 20 deg. This indicates a ready means of concentrating the emanation.—R. Hoffman, Physikalische Zeitschrift, June 1, 1905.

Lippmann's Color Photography.—G. Lippmann describes a method of retaining the colors in his photographs even when they are dry. He uses plates of bichromated gelatine placed with the film side against a mercury mirror. The plates are exposed until the image appears in brown. They are then washed in water. The bichromate is washed out, and the colors appear at the same time. The structure of the gelatine has evidently been altered in the same manner as in the silver bromide plates. When the plates dry up the colors disappear, but they reappear on slight moistening. The author next endeavored to make them permanent. For this purpose he washed them, after drying, in potassium iodide, and found that the colors were feebly visible after drying. He then immersed them in a 20 per cent solution of silver nitrate. The colors then became very brilliant, and remained so after drying. The plates still remain transparent, so that the silver iodide is deposited in a state of solid solution. Viewed with transmitted light, the colors are also brilliant, but complementary. It remains to make the process more sensitive in order to be able to reproduce copies as in ordinary photography.—G. Lippmann, Comptes Rendus, June 5, 1905.

Dynamics of the Electron.—H. Poincaré examines the consequences of our failure to determine the motion of the earth with respect to the ether by means of aberration observations. Since Michelson has failed to obtain even an effect proportional to the square of velocity, it has become probable that we shall never succeed in demonstrating absolute motion, since our measuring instruments compensate the length to be measured by a change of length of their own. Lorentz has shown that the equations of the electromagnetic field are not altered by a transformation such as this: $x' = kl\,(x + \epsilon t)$, $y' = ly$, $z' = lz$, $t' = kl\,(t + \epsilon x)$, which the author calls the Lorentz transformation. But not only E.M.F.'s, but all forces, are affected in the same manner by absolute motion. The electron itself is compressed in its direction of motion, and becomes an ellipsoid, and this furnishes a complete compensation provided the inertia is altogether electromagnetic. The author now proceeds to the conclusion that gravitational force is equally affected, and that it is propagated with the velocity of light. He shows that the two suppositions, when taken together, are consistent with astronomical observation. Laplace's proof that gravitation is propagated with infinite speed only holds good on the supposition that it is unaffected by relative motion. The author shows that the difference between simple instantaneous attraction and an attraction propagated with the velocity of light becomes 10,000 times smaller than it was in Laplace's theory, but that it might still be discovered by careful observation.—H. Poincaré, Comptes Rendus, June 5, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

## CONCRETE.

By BRYSSON CUNNINGHAM, B.E., Assoc.M.Inst.C.E.

CONCRETE is the name applied to an artificial combination of various mineral substances which, under chemical action, become incorporated into a solid mass. Such is the common, and all but universal, signification of the word. There are, however, one or two compositions of comparatively trifling importance which receive the same appellation, though differing fundamentally from true concrete, their solidification being quite independent of chemical influence. These compositions only call for passing mention; they are: *tar*

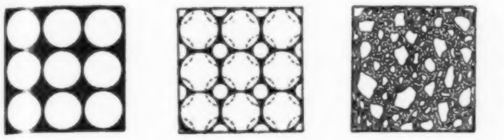


FIG. 1. FIG. 2. FIG. 3.

*concrete*, made of broken stones (macadam) and tar; *iron concrete*, composed of iron turnings, asphalt, bitumen, and pitch; and *lead concrete*, consisting of broken bricks set in molten lead. The last two varieties, with rare exceptions, are only used in connection with military engineering, such as for fortifications and the like; and all three lie outside the scope of the present paper.

Reverting to the first enunciated and most important (as it is by far the most prevalent) conception of concrete, we may particularize its composition by stating that it consists essentially of two groups or classes of ingredients. The first, termed the *aggregate*, is a heterogeneous mass, in itself inactive, of mineral material such as shingle, broken stone, broken brick, gravel, and sand. These are the substances most commonly in evidence, but other ingredients are also occasionally employed, such as slag from iron furnaces. Burnt clay, in any form, and earthenware, make admirable material for incorporation.

The second class constitutes the active agency which produces adhesion and solidification. It is termed the matrix, and consists of hydraulic lime or cement, combined with water.

The foregoing method of classification is simple and

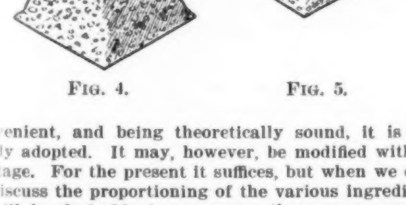


FIG. 4. FIG. 5.

convenient, and being theoretically sound, it is generally adopted. It may, however, be modified with advantage. For the present it suffices, but when we come to discuss the proportioning of the various ingredients, it will be desirable to rearrange the groups more in accordance with practical purposes.

Before entering upon a detailed consideration of the preparation and uses of concrete, it seems fitting to allude to the fact that concrete is by no means a purely modern invention. On the contrary, it is of a very respectable and even venerable antiquity. It would be difficult to assign an exact date to its origin, but it certainly was in use in the time of the Romans and Carthaginians, as is evidenced by the remains of many of their harbors and other maritime works upon the coasts of Italy and Northern Africa. Yet, in spite of its antiquity, it is only of late years—within the last generation, in fact—that it has acquired the peculiar and pre-eminent position which it now possesses in structural work. Associated with steel, it may, without fear of contradiction, be said to be the most popular and useful building material of the present day. Not only is it used for a vastly preponderating proportion

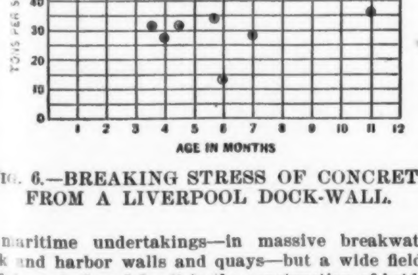



FIG. 6.—BREAKING STRESS OF CONCRETE FROM A LIVERPOOL DOCK-WALL.

of maritime undertakings—in massive breakwaters, dock and harbor walls and quays—but a wide field of usefulness is found for it in the construction of bridges, arches, dams, culverts, viaducts, roads, sewers, warehouses, and buildings of every description. Private residences are built of it, in some cases almost entirely. A well-known engineer relates how, on one occasion, he came across an Irish farmer, who was so captivated with the marvelous adaptability of concrete that he practically rebuilt his farmhouse, the barns and stables, the pigsty and dog-kennel, with the material, and then expressed regret at being unable to make it up into fire-barred gates. That was twenty years ago. Probably by this time the farmer has been able to make his gates. With the agency of ferro-concrete the project is quite feasible, and by no means so ludicrous as it would appear. Much more slender things than farm gates are made of ferro-concrete—skylight bars and louvre ventilators, for instance—while floor joists and beams, columns, bearing and sheeting piles, are but a few of its many and varied uses.

Earlier concretes were manufactured with lime, and not with cement, as is almost universally the practice at present. Portland cement, the best and strongest of modern cements, was of course unknown, being only invented in 1824. Other and natural cements may have been at the disposal of the ancients, but this is doubtful. Hydraulic lime was the main, if not the sole matrix employed. The inferior strength and setting qualities of this material may possibly account for the indifferent popularity of concrete during the middle ages. Yet it is a significant fact that French and Italian engineers of the present day favor the use of lime for concrete—no doubt on account of the exceptionally excellent qualities of the limestones found along the coasts of the Mediterranean. Another reason for the comparatively restricted use of concrete in mediæval times is possibly to be found in the higher value which was then attached to æsthetic over purely utilitarian construction, and the enormous amount of time and labor devoted to artistic production. A Gothic cathedral would lose much of its impressive grandeur if modeled, however skillfully, in concrete. Nothing at the present day looks more pitifully meretricious and tawdry than elaborate and pretentious ornamentation executed in cement-faced concrete, professedly in imitation of masonry dressings; and scarcely anything could be in worse taste. Concrete is essentially a material for strength, for durability, and for economy; in artistic qualities it is much the inferior of natural stone. The most valuable of all the characteristics of concrete is its resistance to the action of fire, and this crowning attribute serves to emphasize the true sphere of its usefulness, viz., as an inestimable structural material for the body of a building, but not for its face or ornamental features.

position of concrete is settled in a very haphazard manner. It is no uncommon experience to find specifications in which one part of cement is assigned to so many parts of gravel, sand, and broken stone, without apparently any systematic determination as to whether the sand and cement combined will entirely fill the interstices in the larger material, or whether again the sand is of the exact quantity required to form a trustworthy mortar with the cement. These two points call for investigation at the outset. We shall therefore proceed to deal with them.

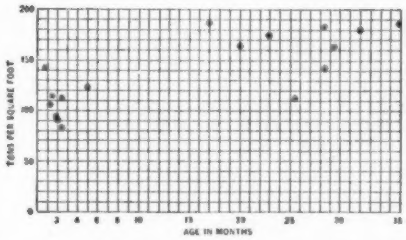



FIG. 7.—BREAKING STRESS OF CONCRETE FROM VYRNWY DAM.

Stated briefly, the problem before us is to determine the relative proportions of cement, sand, gravel, and mineral fragments which go to form satisfactory concrete. For this purpose it is desirable to rearrange our preliminary classification, and to restrict the term "aggregate" to the coarser material, viz., the gravel, broken stone, and brick, etc., as the case may be. The sand and cement may now be allied as "mortar," and the main idea in the ensuing investigation will be that the aggregate must be thoroughly and efficiently bedded in mortar, much in the same way as stone in ordinary masonry. It is necessary, however, to point out that concrete may be made without sand, but that such a modification in its composition would entail the introduction of a far higher proportion of cement in order to fill the greater vacuities among the coarser fragments. This method, therefore, does not lend itself to economical construction.

Before going further there are two postulates to be made which are founded on actual experiment:

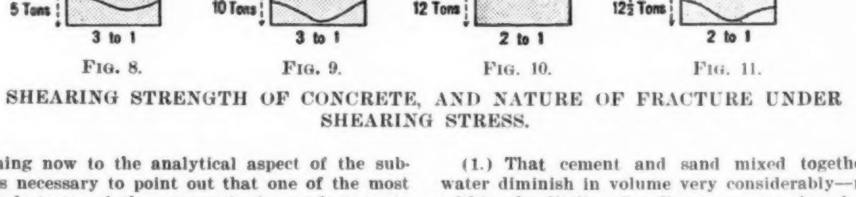



FIG. 8. FIG. 9. FIG. 10. FIG. 11.

SHEARING STRENGTH OF CONCRETE, AND NATURE OF FRACTURE UNDER SHEARING STRESS.

Returning now to the analytical aspect of the subject, it is necessary to point out that one of the most essential features of the aggregate in good concrete is cleanliness and an entire absence of dirt, dust, greasy matter and impurities of any description whatever. The material will preferably be sharp and angular, with a rough, porous surface, to which the matrix will more readily adhere than to smooth, vitreous substances. The specific gravity of the aggregate will depend upon the purpose for which the concrete is to be used. For beams and lintels, a light aggregate, such as coke breeze from gasworks, is permissible, especially when the work is designed to receive nails. On the other hand, for retaining walls, the heaviest possible aggregate is desirable on the grounds of stability.

The aggregate should by no means be uniform in size. Fragments of different dimensions are most essential, so that the smaller material may fill up the interstices of the larger. It is not infrequently stipulated by engineers that no individual fragment shall be more than four inches across, and the material is often specified to pass through a ring 1½ to 2 inches in diameter. The absolute limits to size for the aggregate, however, are determinable by a number of considerations, not the least important of which is the magnitude and bulk of the work in which it is to be employed. The particles of sand should also be of varying degrees of coarseness. A fine, dust-like sand is objectionable; its minute subdivision prevents complete contact with the cement on all its faces. Another desideratum is that the particles should not be too spherical, a condition brought about by continued attrition. Hence, pit sand is better in many cases than river sand or shore sand.

The matrix is almost universally Portland cement, but as this material has formed the basis of a previous article, it is not necessary to dwell further upon its properties. It only remains to be said that the cement should not be used in too "hot" a condition, to which end it is usually spread over a wooden floor to a depth of a few inches, for a few days prior to use. By this means, the aluminate of lime becomes partially hydrated, and its activity is thereby modified. Roman cement and hydraulic lime, which may also be used as matrices, have been previously dealt with.

It now devolves upon us to take into consideration the correct proportions of the various ingredients. This is a most important matter; and it is strange, besides being regrettable, that in many cases the com-

(1.) That cement and sand mixed together with water diminish in volume very considerably—roughly, within the limits of ordinary mortar, by about one-fourth of their joint bulk in the separate dry condition.

(2.) That gravel and broken stone, when intimately combined, occupy less space than they do apart. This fact scarcely needs statement, it is almost sufficiently obvious of itself, for it takes very little consideration to perceive that much of the gravel will be absorbed by the vacuities in the broken stone. In spite, however, of the absurdity of the notion, not a few people seem to entertain the fallacy that, say, two parts of gravel and four parts of broken stone make six parts of aggregate. Such would, of course, only be the case if the broken stone were as small as the gravel, a condition which is practically inconceivable. It is quite possible, and far more likely, that there would be no more than four parts of aggregate. At any rate, the exact quantity lies somewhere between the two extremes, and is a point to be determined.

Manifestly it depends very largely on the relative size and shape of the component particles. Suppose, however, we take a purely theoretical, and even fanciful case, in which the aggregate consists of a number of exactly uniform spheres or globules. It will be found that these spheres can be arranged in contact

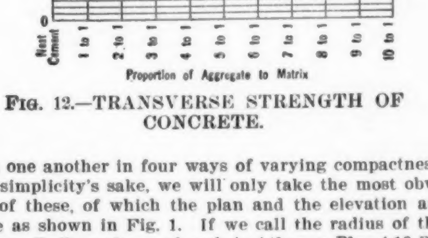



FIG. 12.—TRANSVERSE STRENGTH OF CONCRETE.

with one another in four ways of varying compactness. For simplicity's sake, we will only take the most obvious of these, of which the plan and the elevation are alike as shown in Fig. 1. If we call the radius of the spheres $R$, the volume of each is $4/3 = \pi R^3 = 4.18 R^3$; and the solid content of the cube, a section of which is shown in the diagram $= 3^3 \times 4.18 R^3$. The volume

of the cube itself is $(6\,R)^3 = 216\,R^3$. Therefore, empty

$$\text{space} = 100\left(1 - \frac{27 \times 4.18\,R^3}{216\,R^3}\right) = 47.64 \text{ per cent of}$$

total space.

Now if the vacuities between the spheres be occupied by smaller spheres ($r = 0.732R$) which just touch the surfaces of the larger spheres (Fig. 2), it will be found that the percentage of empty space falls to 27.12; so that the solid content of the whole has been increased by nearly 50 per cent without the least increase in volume. And this is what occurs, in principle, when gravel is mixed with fragments of broken stone (Fig. 3).

From the irregularity and angular nature of these materials, it might be supposed that their actual percentages of empty space would differ very widely from the foregoing standard. Yet such is not the case. The approximation is even so close as to be striking. Thus, the interstices in broken stone of large size, in fragments varying from 3 inches to 6 inches across, amount on an average to 50 per cent of the gross bulk of the stone. Combined with gravel ranging in size from large peas to pebbles 2 inches or 2½ inches across, the net vacuities may be taken at about 30 per cent.

Having settled these preliminaries, we may now devote ourselves to determining the proper proportion (*a*) sand to cement and (*b*) mortar to aggregate.

The first point is settled by judgment and experience, the second by computation. Portland cement will take a larger proportion of sand than either Roman cement or hydraulic lime; but with the larger ratios of sand, its tenacity is, of course, correspondingly reduced. One part of cement to four parts of sand should therefore be looked upon as the upper limit, while for the strongest mortar the proportion need hardly exceed one part of cement to one and a half or two parts of sand. In the ensuing calculations we shall strike a mean, and assume a ratio of one to three. For impermeability, the proportion of one to two should be observed, and for Roman cement this proportion should never be exceeded. The ratio will even advantageously be limited to 2 : 3. For hydraulic lime equal parts of sand and cement are suitable, though two parts of sand to one part of cement may be used.

The quantity of mortar required in reference to the aggregate is based on the vacuities in the latter. For any particular aggregate the amount of empty space may be determined by filling a tank of known volume with the minerals and then adding sufficient water to bring to a level surface. The volume of water added (provided, of course, the aggregate be impervious or previously saturated) gives the net volume of mortar required. To this, however, it is necessary to make some addition (say 10 per cent of the whole), in order to insure the thorough flushing of every part of the work.

Assuming that the proportion of interstices, as previously indicated, is 30 per cent, and adding 10 for the reason just stated, we derive 40 parts as the quantity of mortar to 100 — 10 = 90 parts of the aggregate. An allowance of one-fourth volume for shrinkage brings the volume of the dry materials (sand and cement) of the mortar to 40 + 40/3 = 53 1-3 parts, which, divided in the ratio of 1 to 3, yields:

| | | |
|---|---|---|
| Cement $\frac{53\ 1\text{-}3}{4}$ = | 13 1-3 | parts. |
| Sand ¾ × 53 1-3 = | 40 | parts. |
| Aggregate | 90 | parts. |
| Total | 143 1-3 | parts. |

As the resultant concrete is 100 parts, the total shrinkage is 30 per cent. Expressed in terms of the cement, the concrete would have a composition of 1 cement, 3 sand, 7 gravel and broken stone, and it would form, approximately, what is commonly known as 7 to 1 concrete.

There are, of course, other ratios depending on the proportion of sand. Thus we have:

| Cement. | Sand. | Aggregate. |
|---|---|---|
| 1 | 1 1-2 | 4 1-3 |
| 1 | 2 | 5 |
| 1 | 2 1-2 | 6 |
| 1 | 3 | 7 |
| 1 | 3 1-2 | 7 1-2 |
| 1 | 4 | 8 1-4 |

The cost of concrete may be very materially reduced without affecting the strength or efficacy of the work, by a plentiful use of stone "plums" or "burrs." These are bedded in the fluid concrete during its deposition *in situ*, but care must be taken to see that they are thoroughly surrounded by mortar and not in contact with each other. Furthermore, if they are of a porous nature, they should be wetted well before use.

The mixing of concrete is an important matter. If done by hand, the materials forming the aggregate will be laid out on a platform and covered by the cement in a thin layer. The whole should be turned over thrice in the dry state, and as many times wet, before depositing, in order to bring about thorough and complete amalgamation. Once mixed, the concrete is to be deposited immediately and allowed to remain undisturbed until the action of setting is finished. Deposition should be effected, wherever possible, without tipping from a height of more than about six feet, as in greater falls there is a likelihood of the heavier portions of the aggregate separating from the lighter. In extensive undertakings, concrete is more economically mixed by mechanical appliances.

The water used for mixing may be either salt or fresh, so far as the strength of the concrete is concerned. But for surface work above the ground level, salinity in any of the ingredients is objectionable, since it tends to produce efflorescence—an unsightly, floury deposit, difficult to get rid of. The quantity of water required cannot be stated wih exactitude; it will depend upon the proportion of the aggregate and its porosity. It is best determined by experiment in each particular case. Without being profuse enough to "drown" the concrete, it should be plentiful enough to act as an efficient intermediary between every particle of the aggregate and every particle of the matrix. Insufficient moisture is, in fact, as deleterious as an excess.

The matter is a contentious one, and it has been the subject of considerable divergency of opinion. There are well-known authorities who advocate a very sparing use of water, and who recommend the treatment of concrete by continuous beating, so as eventually to cause moisture to appear upon its surface, in the same way as it appears upon the surface of damp sand under similar treatment. The process, however, is tedious and expensive, and it is not apparent that the results are altogether commensurate with the trouble taken to obtain them. No doubt the compressive strength of such concrete is high, but, in the majority of cases, the lower value attained without any elaborate operations is serviceable enough at a much less cost. Then, again, it is a difficult matter to gage the exact minimum of water required, and any undue paucity fails to produce that thorough chemical action which is essential to soundness and durability. Cases have occurred in which the insufficiently hydrated particles of cement have been washed out of the pores of the concrete at a later stage when exposed after induration to the action of running water, thus leaving the work in a honeycombed and pervious condition. The writer's experience has been that a well-watered concrete, of the viscous consistency of honey or treacle, yields an excellent material, sound, durable, and hard, answering all the exacting requirements of maritime engineering work.

This brings us to the question of strength. The testing of concrete is chiefly confined to a determination of its compressive strength, the use of concrete in tension being avoided in sound design. The wide range of results obtained by experiment is evidence of the very variable nature of its resistance. The method of testing is that of making small cubes, from 6 to 24 inches side, and crushing to failure. The manner in which failure takes place is somewhat striking. In the majority of cases, the cube fractures in such a way as to leave a pyramidal structure, either single or double, as shown in Figs. 4 and 5. Some typical numerical results are illustrated graphically in the ensuing figures. The set in Fig. 6 relate to concrete used at one of the Liverpool docks; the blocks, the surfaces of which were somewhat rough and not specially prepared for the testing machine, contained eight parts of gravel and sand to one of cement. There can be no doubt that with specially prepared surfaces much higher results would have been obtained. The set in Fig. 7 are values obtained by Prof. Unwin from sample cubes of the concrete used in the construction of the Vyrnwy dam; its composition was six parts of gravel and broken stone to one of cement. The latter results are very high, but still higher records afford conspicuous evidence of the careful and systematic manner in which the work was punned and consolidated. Of blocks cut out of the hearting of the actual structure, at different depths and therefore of different ages, the lowest resistance to cracking under compression was 184.4 tons per square foot in the case of a block about nineteen months old, and the highest was 329.5 tons per square foot in the case of a block two years old; while the mean resistance of nineteen blocks, between one and two years old, was 263 tons per square foot.

The effect of testing concrete in shear in a few experiments is shown in Figs. 8 to 11, as also the lines of fracture. The dimensions of the blocks tested were 9 inches by 12 inches by 12 inches. The result obtained in the first case is very low and possibly due to some latent imperfection.

Concrete has also been tested, in certain instances, in regard to its transverse strength. These results, reduced to their equivalent values for a beam twelve inches square in cross section and twelve inches long between supports, are exhibited in Fig. 12. The weight given is the breaking load applied centrally.

In dealing with concrete it cannot but be conceded that there are quite a number of practical points, relating to its adaptability to various situations, which would have called for notice, had it been feasible to discuss the subject at greater length. The foregoing observations, however, will suffice to cover in a general way the very many interesting issues which lie within the range of a topic of such widespread importance.—Technics.

## AN ISLAND PRISON ON THE FORTH.*

AN immense rock, higher than the dome of St. Paul's, a mile in circumference, the Bass stands like a white-walled, grass-grown monument in the flood of the Forth. In a wide arm of the sea, sparsely studded with islands, the Bass might seem an uninteresting dot on the face of the waters. But history is never dull; and from the earliest times the Bass has history—the human history of those who inhabited it, the natural history of the bird-life that makes the distinctive feature of the Rock.

The Church, who, whatever her schisms, has seldom been idle throughout the ages, leaves the first record of habitation on the Bass. During the sixth century a saint of Northumbrian descent, St. Baldred, known as the "Hermit of Bass," took up his abode on the island. Actual information about him is slight, and much legend has gathered round his name. He seems not to have been a recluse or hermit in the full sense of the word, but a missionary preacher who at times retired to this fastness—as St. Cuthbert, another great Northumbrian saint, did to the Farne Island—as a religious retreat, or perhaps for safety; sallying forth again when the spirit called him to propagate the faith on the mainland. The scene of his missionary labors embraced the whole countryside from Lammermoor to Inveresk. His memory is preserved in a rock called St. Baldred's Cradle, in St. Baldred's Well, and St. Baldred's Statue (demolished by a skeptical mason). In 606 the saint died on the Bass. Then occurred one of those miracles of the early ages related in the Breviary of Aberdeen. Dispute arose among the parishes of Auldhame, Tyninghame, and Preston for the right of giving so great a man a burying place. As the disputants could not agree, his body was left unburied. When the following morning dawned, in each village lay a St. Baldred dressed for burial. Explanation of such phenomena was neither asked nor received in those days. The ruined chapel on the Bass may mark the site of the hermit's cell. Built long after his death, in the fourteenth century, it bears the name of St. Baldred. With the Reformation this little sanctuary fell into disuse. No service was held there while the Bass was a fortified garrison. Nevertheless, a young lady was then supposed to have been received by some means into the Romish faith, in the presence of the keeper of the Bass and his boat assistant.

In 1405 the Bass is mentioned as being fortified. The first State prisoner was Walter Stewart, son of the Duke of Albany. His father was at the same time imprisoned at Caerlaverock, as his mother was at Tantallon, whence she watched her son removed to execution at Stirling. The fourteenth century saw an attempt on the part of the English to take possession of the Bass; but the ships dragged their anchors and the expedition failed. For generations the Bass was the property of the Lauders. In the aisle of the old kirk of North Berwick there was once a tomb with an inscription to this effect: "Here lies good Robert Lauder, the great laird of Congalton and the Bass, who died May, 1311." The same Robert was the builder of the castle on the Bass, where Maggie Lauder, a heroine of Scottish song, is reputed to have been born. In the reign of Charles I. the Rock was held by George Lauder and Dame Isobell Hepburn, his wife. James VI. visited the Bass during the possession of the Lauders, from whom he wished to purchase it. Perhaps he saw what an enchanting summer residence might be fashioned out of such unique material. But the Lauders, who were ever persons of a lively spirit, did not part with their belongings so easily. "Your Majesty," said the owner, "must e'en resign it to me, for I'll have the 'Auld Craig' back again." The Lauders took for their crest a solan-goose, the bird being the principal inhabitant of the Bass; for their motto, "*Sub umbra alarum tuarum*"—translated, "Under the shadow of thy wings." Their solan-goose sheltered them as the eagle of Dante spread his pinions over the world.

In the time of Cromwell the Bass became a place of safety for the keeping of valuables. Among others, the public records of the Church of Scotland found shelter in this storehouse. The Laird of Waughton, who owned the island in the commonwealth, received and cherished these documents; but the Bass, hitherto considered impregnable, surrendered to Cromwell. The precious papers of the Kirk were taken in a cask to the Tower of London. They returned later to Scotland, again traveled to England, and are thought to have perished in the fire at the House of Commons in 1834. The Bass passed from the Laird of Waughton to Lord Lauderdale, who purchased it for a State prison. It was observed to be a dear bargain by a contemporary, who remarks: "Sir Andrew Ramsay having, neither for a just price nor by the fairest of means, got title to a bare insignificant rock in the sea called the Bass, and to a public debt, both belonging to the Lord of Waughton, my Lord Lauderdale, to gratify Sir Andrew, moves the King, upon pretence of this public debt, and that the Bass was a place of strength (like to a castle in the moon), and of great importance (the only nest of solan geese in these parts), to buy the Rock at the rate of £4,000 sterling, and thus obtains the command and profit of it, amounting to more than £100 sterling yearly, to be bestowed upon himself." Lauderdale, in addition to his other titles, was given that of "Captain of the Bass." The property afterward came into the possession of the Dalrymples, who retained it till it was acquired by the present owners.

The King (Charles II.) converted the Bass into a prison for the Presbyterian ministers in the struggle between prelates and presbyters—but one of too many instances of Protestant persecution, as Blackness and Dunnottar can also testify. Accounts of the prison represent it as being an abode of great discomfort. It was situated on a ledge at the base of the hill. Constant droppings of moisture fell upon it from above; the spray of the ocean washed up to it from below; the four winds of heaven blew around it. The food was bad, often insufficient, from the difficulty of boats reaching the Rock in bad weather. All the chimneys smoked. The prisoners were severely kept, not being always allowed to take exercise in the walks of the island. John Blackadder, minister of Troqueer in Galloway, one of the most noticeable of the "martyrs of the Bass," endured a captivity of five years, and died

* Chambers's Journal.

on the Rock. His cell, called "Blackadder's Cell" to this day, is now so choked with fallen stones and rubbish that it is almost impossible to reconstruct the dimensions in imagination. It was described as a room about seven by eight feet, having three small windows. One of these gave a glimpse of the sea; the second showed a strip of sky; the third looked on to a narrow passage whence the prisoner could be observed by the sentry on duty. There was another cell of even more dismal aspect, where Thomas Hog, of Kilburn, was imprisoned by Archbishop Sharpe. A vaulted staircase led down from the eastern end of the castle to what was formerly called the Bastion. Here was a horrible cavern, dank and dripping, with an opening toward the sea, which dashed up almost to the entrance.

Blackadder is buried in the old kirk at North Berwick. A narrow lane in the old town called the Kirk Ports leads from Quality Street to this partially-restored ruin. In the churchyard a gray stone planted about with shrubs and ivy marks the grave of Blackadder. At the beginning of the last century, it was renewed. The inscription recording the age, imprisonment, and death of Blackadder is followed by some lines comparing his incarceration on the Bass to that of St. John in Patmos. High-flown and old-fashioned, the note yet strikes true, making the reader realize that Blackadder, however unsympathetic his opinions, was a soul of some rarity.

Fraser, of Brea, who, despite imprisonment, was able to appreciate the Bass Rock, wrote an account during his sojourn there having a singular charm. He tells of the inaccessibility of the island, the difficulties of landing, the mighty force of the waters breaking against the cliffs; of the governor's house, the prison, the chapel used for storing ammunition; the garden, where herbs and gean trees grew; the walks on the Rock evidently of a quarter-deck length, paced repeatedly by weary feet carrying weary hearts; others more circuitous and solitary, where the prisoners could give way unobserved to conversation, meditation, or despair. Cannon were placed in several parts of the island—an almost unnecessary safeguard, for Nature had provided the best defense in the natural stronghold. Twenty-four men formed the garrison, a company sufficient to defend it against an army in those days. An equal number of sheep cropped the grass on the hill behind the buildings. Mr. Fraser found his imprisonment less irksome than did many of the thirty-nine prisoners. He studied Greek and Hebrew; he read divinity; he wrote a treatise on faith. Despair was not altogether the portion of these indomitable Scotch ministers. Another writes: "Since I was a prisoner I dwelt at ease, and lived securely. The upper springs flowed liberally and sweetly when the nether springs were embittered."

In December, 1688, beacons blazed on the Bass, North Berwick Law, and the neighboring heights, a warning that William of Orange was about to invade Great Britain. Then took place the ignominious flight of the Earl of Perth, the notorious and detested chancellor, who was also governor of the Bass. From Kirkcaldy he sailed down the Forth in a sloop, disguised as a woman, his wife accompanying him in man's clothing; but was caught and brought back to a five years' imprisonment. The Bass did not easily succumb to Dutch William and his followers. It claims the distinction of being the last place in Scotland that held out for the Stuarts. Charles Maitland, the deputy governor, ceded his post in 1690. Even later it was garrisoned by a few daring young officers, who led the life of pirates. They sallied forth, plundered passing vessels, and, craning their boats up the face of the Rock, resisted attempts to dislodge them. Finally their supplies were cut off by warships sent by the government. An order given at this juncture to demolish all fortifications and remove the cannon was disregarded. Many years elapsed before all such traces were destroyed and the prisons allowed to fall into disrepair. The right of fortifying the Rock in time of war still exists. Up to the middle of the eighteenth century it was garrisoned by a company of the Scots Guards, more than fifty years after the regiment had been transferred to London. The soldiers received extra pay in consideration of their exile. Through the great heart of the Bass there runs a natural channel leading onto a beach of fine white sand, never covered except at flood tides. It was the scene where a novelist made an escaping prisoner take refuge, and be rescued by a fishing smack. Real life is more ruthless than fiction. No prisoner ever escaped from the Bass save by death. The strength of the Bass has passed into a local proverb:

Ding doun the Bass,<br>Mak' a brig to Tantallon,

being a phrase used to express achieving the impossible.

Old prints of the Bass in a fortified state during the seventeenth century show the Rock ascending steeply from the sea to a level platform. A crane used for raising provisions, ammunition, and boats stood on the platform. Behind was the governor's house and the towers connected by curtain walls. The prisons were situated in the center of the inclosure. Only the roof and chimneys were visible from the exterior, thus shutting off the prisoners from any possible signaling with the outer world.

All this has been considerably altered with the course of time. A flight of steps cut in the wall of the Rock leads down to the waters, at some places forty fathoms deep, that surge and eddy and lap around the rugged mass. Above the steps, a stone path and stairs laid on the Rock ascend to the locked gate guarding the buildings. On the other side of the gate are the remains of the prisons and cells, a heap of broken masonry, a chaos of tumbling stones. The path winds from them, turning onto a paved terrace in front of the lighthouse erected within the last two or three years. Beyond the lighthouse it passes a deep gully, where, far below, the restless waters of the Forth, ceaseless in motion as the ear of a horse, run into a creek, till it reaches the ruins of the chapel. Ever upward goes the path, in the tracks described by Fraser, of Brea, to the garden sunk into a hollow, protected by the rise of the hill. It is but a square encompassed by four low, tottering walls. Rank grass and nettles appear to be the only growth, though perchance at different seasons of the year there may bloom stray spring flowers, or summer see the Bass mallow and seapink in blossom. In the center of the garden is the water spring, now a covered well. Mounting from the garden, leaping over a network of rabbit holes so numberless that the solid earth is more infrequent than the holes, one reaches the cairn on the summit of the Bass. The explorer looks up and down the Forth, far as the eye will travel, to the open sea that broadens to the Atlantic roll; to the islands of the May and Fidra; to the mound of Craigleith, the building place of puffins and guillemots; to the shores of Fife and the range of violet hills against the sky; to Tantallon Castle, the red roofs of North Berwick, past the stately pile of Gosford hidden in the woods to the outline of one of the beautiful cities of the world.

Visitors to the Bass have always been numerous. In former days they were said to be made burgesses of the Bass by the offering of a drink of water from the well and a flower from the garden. This poetic rite is replaced in the commercial twentieth century by a charge of ten shillings for the hire of the key of the gate of the ruins. Three Kings of Scotland journeyed thither: the first, fourth, and sixth of the Jameses. Hector Bocce found "everything in this crag ful of wounder and admiration." Jean de Beaugue, a Frenchman who came to Scotland in 1548, visited the Bass. He found a garrison of five or six score men. The only means of egress from the fort to the boat was a basket. John Ray, the naturalist, and Harvey, the discoverer of the circulation of the blood, explored the Bass in the seventeenth century. Hugh Miller and several historians and botanists have recorded their impressions. In summer a steam launch conveys tourists across from Canty Bay. Hardened voyagers sail from North Berwick. The golfers of these links do not largely swell this maritime traffic. To appreciate the "Auld Craig" fully it must be seen at every hour, at every turn of tide watched from the coast till each aspect of an endless variety is familiar. Sometimes standing out sharp and bright, the cliffs white, the grass green against an azure sky and ocean, a gorgeous jewel on the breast of that Amazon, the sea; sometimes seeming very near inshore, with white horses dancing on the waters; at other moments gray, sullen, menacing, dull of color, angry waves tearing at the base; or else mysterious, a dim form in the mist of dawn or twilight, shrouded in a gray veil, withdrawn into impenetrable surroundings; or, it may be, blotted out altogether, a faint darkness below the horizon alone marking the position; at night, silvered by moon-rays across the Firth, flashing from a thousand iridescent facets the blinding glare of its own danger-signal. Those who live beside the Bass grow to love it for its very ruggedness and bleakness. The more delicate fancies of Nature may captivate and delight; the Bass will arrest and hold by main force.

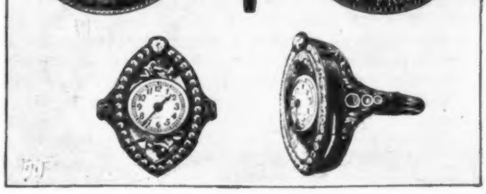
Of the many owners of this island fortress, one family has remained in possession throughout all time. No date is fixed for the colonization of the Rock by the birds of the Bass. The very earliest historians mention the solan geese as the first inhabitants, imagining them, in the strange errors of the day, to be a miraculous birth from barnacles. Since then the different varieties of sea fowl that make their home there have increased to the number of ten or twelve. The solan goose or gannet extends its flight to great distances: some have been seen on the coast of Greenland; southward they go as far as the south of Portugal. They are said to leave and return to the Bass on the same day, year after year. A tithe of twelve solan geese with their feathers on was annually paid to the minister of North Berwick, at one time called the vicar of the Bass, till recently.

The sea birds have chosen this huge rock for an abiding nesting place; their freehold of this ocean citadel is sure as any ownership of man. Three sides of it slope sheer down into the sea. In every niche and cranny of the cliffs are birds, thousands of families, a population of bird-life seemingly vast as the population of some thickly inhabited town. On the top of the Rock they are congregated in armies, close set in serried ranks, bird to bird, hardly a blade of grass between them—birds, birds, birds. Round about the island the air is filled with birds; white wings are whirring overhead, soaring out into the blue; shrill cries resounding, clattering like stones on ice through the clear metallic air. Human foot seldom sets its daring tread on the outward side of the island, on those rough-hewn stairs of Nature's masonry, where the birds sit and watch with wise eyes the passing of the vessels and of man who fashioned these marvels. The birds are masters of the Rock. The Bass is theirs irrevocably, eternally, writ in a charter of the seas and skies, sealed by ages of succession.

## MASTERPIECES OF WATCHMAKING.

SWITZERLAND has succeeded in monopolizing the export trade in watches to such an extent that many persons might be led to think that France, the country of the Leroys, the Lepantes, the Janviers, and so many other artists in the annals of watchmaking, is relegated to the background of a stage upon which it shone so brilliantly of old, and that it is incapable of maintaining a competition with the great houses of the land beyond the Jura. This would be an error, however, for although Besançon, the seat of the French watch industry, has passed through some crises that might have proved fatal to it, it nevertheless remains a worthy emulator of Geneva, Locle, and Chaux-de-Fonds. France has evidently lost none of its old prestige. Proofs of this may be found at the St. Louis Exposition, and especially in the show case of M. Louis Leroy, of Paris, wherein, among the specimens exhibited, there is one that seems particularly worthy of being brought to the notice of our readers. This is a 100-franc piece with the effigy of the Prince of Monaco and the date of 1901, in which is housed the movement of a watch. The accompanying picture gives obverse, reverse, and edge views of actual size. It will be seen that the winding thumb piece is almost entirely concealed upon the circumference and is scarcely visible.

WATCH IN A 100-FRANC PIECE.

RING-WATCH WITH AUTOMATONS AND A STRIKING-TRAIN.

A few figures will show the difficulties that had to be overcome in order to make the work a success. The maximum thickness of the reliefs is 2.256 millimeters. The minimum thickness in the depressions is but 1.786 millimeters. There remains in the total thickness of the frame containing the wheel-work, complete works, and the stem-winder an available one of but 1.551 millimeters. It will be seen that, under such conditions, each piece of the mechanism had to be made absolutely as thin as possible. There are pieces of brass that are but 14/100 of a millimeter in thickness and pieces of steel that reach scarcely 10/100. The brass wheels are 188/1,000 of a millimeter in diameter. The balance wheel, which is of gold, is 15/100 of a millimeter in thickness. As for the main-spring, that is 445/1,000 of a millimeter in width, and might be confounded with certain hair-springs of chronometers. The steel arbor that carries the minute hand and traverses the entire movement has a total length, head included, of 2.397 millimeters, which represents the general thickness, including the face and hands. The diameter of the movement is 18.791 millimeters; that of the plate for covering the movement, 34.963 millimeters; and that of the face, 24.25 millimeters. The watch is a three-quarter plate one, with side lever escapement and stem winder.

In order to give an idea of the difficulties encountered in the course of construction of this little marvel, we may state that in the movement there are 14 screws instead of the 30 that are usually employed, 16 having been done away with because there was not sufficient thickness to make them hold. In like manner, it was impossible to drill holes for securing the main-spring; and it became necessary to have recourse to special and sometimes new arrangements for the divided arbor of the winding pinion, the setting wheel, etc.

Alongside of this watch figures a ring-watch which is represented of actual size in the accompanying illustration.

The face is situated in the center of a bezel enriched with brilliants. The subjects that complete the ornamentation in the two angles are automatons that operate with the striking train, for this watch is provided with a very complicated mechanism. It has an anchor escapement with compensating balance, and repeats the hours and quarters.

Let us recall the fact that it was the Leroy establishment that in 1900 constructed two curiosities that attracted considerable attention at the time. One of these was a ball-bearing watch and the other an ultra-complicated one. In the latter, the face gave no less than 24 different indications, which were obtained through the assembling of 975 pieces. The ball-bearing watch, which was 43 millimeters in diameter and 6.5 millimeters in thickness, contained 116 balls of which the diameters were ½ and ¼ of a millimeter and which rolled in sapphire cups. It was certainly no trifling matter to make and put in place such minute balls, which had to be absolutely perfect in order to prevent any interference with the running of the movement, which they were, on the contrary, designed to assist.—Translated from La Nature, for the SCIENTIFIC AMERICAN SUPPLEMENT.

## TORSION METER FOR RECORDING THE HORSE-POWER OF STEAM TURBINES.

By the English Correspondent of the Scientific American.

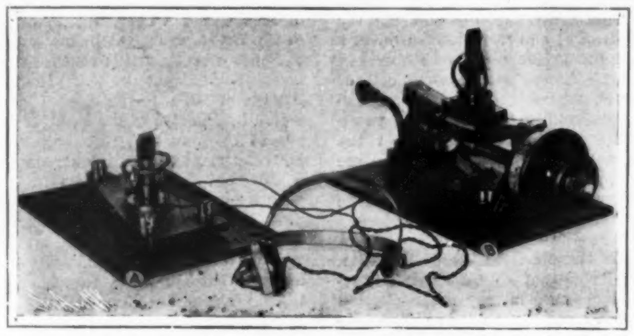
One of the greatest engineering difficulties in connection with steam turbines is the correct calculation of the horse-power developed. Owing to the peculiar features of this system of generating power, the process ordinarily employed is unsuitable, with the result that the data can only be ascertained by dint of careful and prolonged mathematical calculation, and even then the product is only approximate. This drawback has been severely felt by shipbuilders and engineers especially, in view of the fact that the utilization of the steam turbine for marine purposes is being so extensively developed.

The invention of a device therefore whereby the horse-power of this system of developing power can be accurately obtained quickly and readily will commend itself to all those who make use of turbines. This apparatus, which is the joint invention of Mr. Archibald Denny and Mr. Charles Henry Johnson, the electrical engineer to the firm of Messrs. William Denny & Brothers, of Dumbarton, who have been actively engaged in the exploitation of the Hon. C. A. Parsons' invention, is described as a torsion meter, and by its aid the torsion of the revolving shafts can be ascertained, and consequently the horse-power that is being transmitted can be accurately indicated.

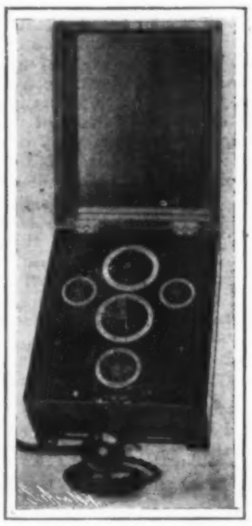
The accompanying photographs, which we are able to publish through the courtesy of the manufacturers of the appliance, Messrs. Kelvin & White, of Glasgow, illustrate the invention, while the diagram comprehensively demonstrates the integral parts of the apparatus and its application to the shafts. Upon the shaft the torsion of which it is desired to ascertain, two light gun-metal wheels, *A* and *B*, are fixed at a convenient distance apart. There is a permanent magnet mounted on each wheel, the projecting pole of which is of V form, so as to produce a dense and definite magnetic field at the point. Beneath these magnets, in a concentric position with the wheels and shaft there are two inductors, *A* and *B*. Each of these latter comprises a quadrant-shaped piece of soft iron which is mounted on a gun-metal stand, which can be leveled by the aid of screws. There are a number of separate but identical windings of insulated wire on each of these pieces of iron, the number of windings being such as to be suitable per unit of circumferential length of the iron. In conjunction with these indicators is a recording box, which contains two series of contact studs, *A* and *B*, and around each of which is attached a scale. Two contact arms, *A* and *B*, are in connection with these arrangements of contact studs, and by means of these arms it is possible to establish electrical connection as desired between it and any desired stud of a series. In series *A* is a stud for every individual winding in the inductor, *B*, each separate stud being connected to its particular winding by a separate wire, while all the wires are contained in the multiple cables, *A* and *B*. Two common wires, which are also contained in the cables, also serve to connect the remaining ends or returns of the windings on the inductors to their respective contact arms.

A variable resistance is included in each of these two circuits, and one winding of a differentially-wound telephone receiver. The inclusion of this variable resistance enables the strength of the potential of the current flowing in the circuit to be altered as required.

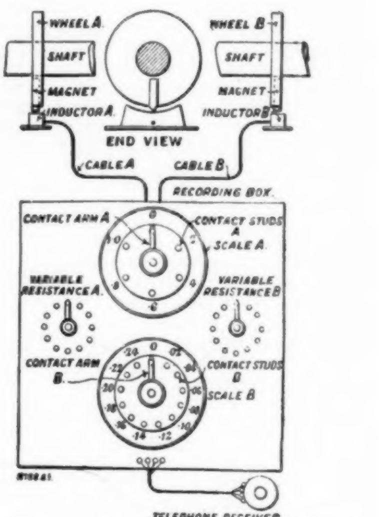
The scale *A* is divided into six equal parts, there being six separate windings in the inductor, *A*, and consequently six studs in the series *A*. The length of five subdivisions of the scale represents the circumferential length occupied by all the windings on the indicator, each subdivision representing one distance between neighboring windings, which is generally 0.2 inch. There are fourteen equal subdivisions on the scale, *B*, fourteen separate windings on the inductor, *B*, and fourteen studs in the series, *B*. As in the previous scale, the length of thirteen subdivisions of this scale represents the circumferential length occupied by all the windings in the inductor, the distance between the neighboring windings being represented by one subdivision of the scale. The usual distance between the neighboring windings in the inductor, *B*, is also generally 0.2 inch; the wheel which is in connection with the inductor at the turbine end of the shaft is so set that the magnet attached thereto is exactly above one of the two end windings in the inductor.



TYPE OF TORSION METER FOR ATTACHMENT TO SLOW-REVOLVING SHAFTS, SHOWING INDUCTORS AND TELEPHONE RECEIVER.



THE TORSION METER FOR APPLICATION TO HIGH-SPEED TURBINE SHAFTS, SHOWING INDICES, CONTACTS, AND SCALES.




TORSION METER APPLIED TO SHAFTING.

THE TORSION METER APPLIED TO A TURBINE SHAFT.

The correct end winding to which the magnet has to be set is that from which the magnet travels toward the other end winding during the rotation of the shaft. The wheel which is in connection with the other inductor is also set in such a manner that its magnet comes exactly above one of the two end windings in the inductor, the correct end winding in this case being that from which the magnet travels in the opposite direction to the other end winding during the rotation of the shaft. The accurate setting of these magnets to the separate windings is facilitated by lines cut in the top of the inductors exactly above the end windings. The magnets are set to these lines. The rotation of the shaft without, however, the transmission of any power induces a current in the end or zero winding of each inductor, the arms of the contacts first being placed in connection with the end or zero stud in each series. Both of these separate currents traverse their respective circuits, and in each instance pass from the inductor winding in which they are induced to the respective zero studs to which these windings are connected, then return to the inductors again through the respective contact arms, resistances, and telephone receiver windings. By suitable arrangement of the connections to the receiver windings the effects of the two separate currents flowing therein are in opposition, and consequently neutralize each other's effect on the receiver when the potentials of the two currents flowing are exactly equal at the same instant. The currents are made equal in strength by the variable resistances in each circuit, and then so long as the shaft transmits no power, and is thus subject to no torsion. No sounds are transmitted to the telephone receiver, owing to the fact that the currents induced in the zero windings have been equalized and are both induced at precisely the same moment. When, however, the shaft transmits power, a certain amount of torsion therein is established, and this action causes the zero windings of the inductor next to the turbine to be excited before the other by the exact extent of the torsion set up in the shaft. A loud ticking sound is then audible at the telephone receiver, owing to the fact that the currents are no longer neutralizing one another.

In operation, the contact arm, *B*, is now moved progressively from one contact stud to the succeeding one, the movement being continued until the position of greatest silence in the receiver is once more obtained. Upon the discovery of this position the reading on the scale, *B*, opposite the contact arm indicates the circumferential measurement of the angle of torsion of the shaft at the radius of the inductor windings. There is at this junction a current of equal potential to that induced in the zero winding of the inductor, *A*, induced in the corresponding winding of the inductor, *B*, connected with the contact arm, *B*, at precisely the same instant. The result is that the

scale reading indicates the displacement of one magnet with regard to the other, brought about by the torsion of the shaft. Should, however, the degree of torsion be too great to read on scale, *B*, the contact arm, *A*, is moved from stud to stud until a reading can be obtained on scale, *A*, the torsion indicator being the aggregate total of the two readings on the two scales, *A* and *B*. It is then easy to obtain by such combined use of the scales, *A* and *B*, the reading corresponding to any large displacement of one magnet relatively to the other.

In the accompanying photograph of the apparatus, an improved form of the torsion meter is shown. This apparatus is the outcome of the five years' experience that has been gained by the use of the instrument already described, and its paramount feature is that it is more applicable to slower speeds of revolution than the original device. In this case the inductor, *A*, is made of a thin soft iron core which is wound with insulated wire. The inductor, *B*, is a similar core and winding, but whereas the *A* inductor is mounted on a base, the second one is on a slider, which is so carried on a quadrant-shaped guide that by the simple turn of a hand wheel the slider which carries the core may be moved either backward or forward along the guide. The telephone receiver is placed in circuit with the two indicators, and each of the latter is set beneath a wheel carrying a magnet. To read the indicator, it is only necessary to move the hand wheel in one or other direction until silence is obtained in the receiver. The extent of adjustment is recorded, and thus gives the degree of torsion on the shaft. One variation of the appliance is that it may be applied to indicate the torsion of shafts driven by reciprocating engines. Owing to the fact, however, that the degree of torsion may vary during a single revolution, which is attributable to the uneven turning movements of steam engines, there are six magnets employed on each wheel instead of one as in the previous instrument, and each of these magnets is placed equidistantly about the circumference of the wheels, and they are each arranged in a different parallel plane.

Any pair of windings on the two inductors can be brought into circuit with the telephone receiver at the same time by means of a switch. Resistances are inserted for the purpose of varying the potentials of the induced currents. The angle of torsion by this apparatus can be ascertained readily at six points of the circumference, and the mean torsion can be quickly resolved during a revolution for any constant condition or short trial. Some idea of the exactitude of this appliance may be gathered from the fact that in a recent trial of unusual severity, the degree of error did not exceed one per cent.

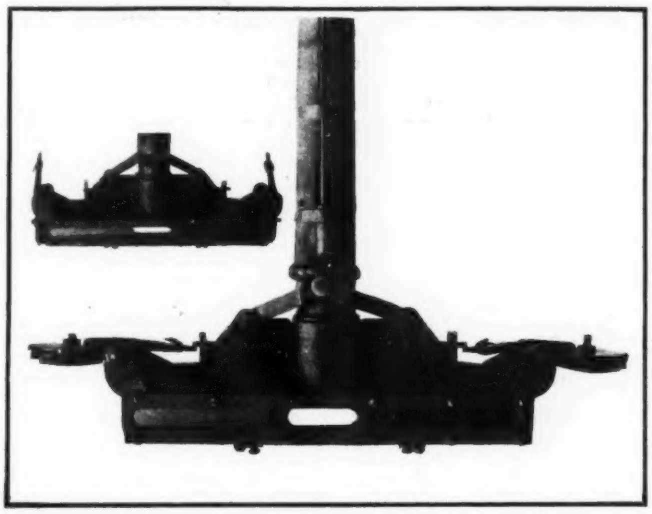
This apparatus has been subjected to some five years' constant service in this class of work before its recent introduction on the market, and its value and efficiency had thus been well established. The instrument has been thoroughly tested on ten different turbine steamers that have been built by Messrs. Denny Brothers, and has proved completely successful, an average accuracy of 99 per cent of readings being easily and quickly obtained. This is of great importance in connection with turbine engines, since the ordinary indicator diagrams have proved unreliable. It may be explained that the inventors have been engaged in the evolution of this appliance for no less than fifteen years. At first it was devised for operation in connection with machine-driven shafting, but was abandoned owing to lack of practical success. The introduction of the steam turbine, however, gave the inventors fresh impetus, and the present instrument is the outcome of their unceasing efforts. A prominent feature of the instrument is its immunity from derangement. The absence of rubbing contacts obviates any possible wear and tear from this source. They require no attention when not in use, while as they generate their own current they are convenient, and form a useful permanent addition to an engine-room equipment, it being possible to take a reading whenever desired with facility and celerity.

As it is important for the purposes of fine adjustments to eliminate as far as possible all outside noise, the recording box is generally placed in a quiet cabin, as by so doing it becomes possible to hear clearly the sounds transmitted to the telephone receiver. A noteworthy improvement which is not shown in the accompanying illustrations has recently been made. This is the addition of a recording instrument, by means of which the revolutions of each engine are indicated by a pen upon a drum of paper. The recording is made by electric contacts. A second pen is connected from the watch of the observer on the bridge who is taking time on the mile, while another pen marks half seconds from a standard clock. The value of this later addition is that the observer in the cabin with the apparatus can carry out his operations independently of information from the engine room. The result of a run both as regards power and speed can be published within a few minutes of the completion of a trial.

## A SAMPLE TAKER FOR USE IN DREDGING OPERATIONS.

By the English Correspondent of Scientific American.

A simple invention, which is of great utility to engineers engaged in dredging operations in estuaries and harbors, has been devised by Mr. G. F. Lyster, the engineer for the Mersey dock authorities. The scope of this device is to render the operations more efficient, and to economize wear and tear upon the machinery, as well as fuel consumption. Every engineer in this ramification of industry fully realizes the importance of ascertaining the percentage of sand or mud contained in the volume passing through the suction pipes. The ratio of water to sand must be reduced to the minimum, since a heavy percentage of water drawn in through the suction pipes involves useless wear and tear upon the machinery and expense of fuel to no purpose. The ordinary gages attached to the pumps certainly indicate, by variations of the pressure, the work which is being carried out, but such results are not entirely satisfactory. It is desirable that they should be supplemented by some method of actually ascertaining the efficiency of the results. This determination can be carried out by means of Mr. Lyster's device.



THE SAMPLE TAKER WITH ITS VALVES OPEN AND CLOSED.

The apparatus, which is called a sample taker, comprises a brass tube about 10 inches in length by 2 inches in diameter. On one side there is a long slit in which a glass is fitted, so that the contents of the tube may be readily inspected when desired. Hinged valves faced with soft India rubber are fitted to the ends of the tube. When these valves are closed, they are pressed strongly against their seatings by means of springs. A portion of the valve is projected beyond the hinge so as to engage with a trigger, and the action of the latter serves to hold the valve open. The tube is fixed to the end of a staff, along which extends a brass rod for actuating the triggers.

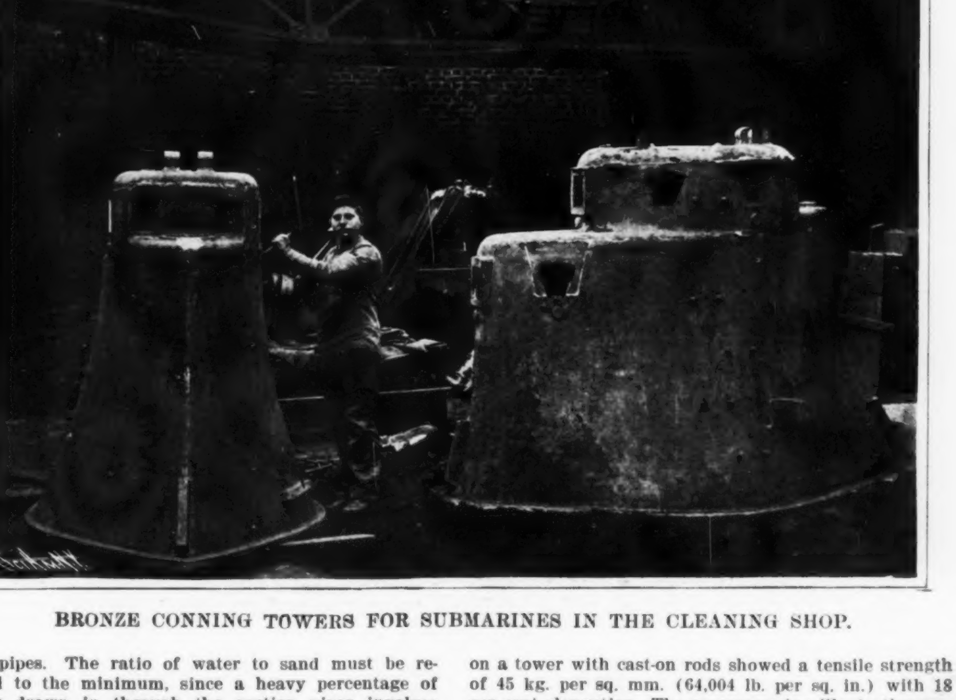
In operation the sampler is lowered with both ends opened in the way of the current of the discharge from the suction pipe, so that the material flows directly through the apparatus. Both ends are closed simultaneously when desired. In this manner the engineer is able to gather practically a sample of the sand and water in the tube. The sampler is then withdrawn and its contents emptied into a long test tube of small diameter, and graduated so that the percentage of solid matter of the whole contents can be quickly gathered.

With this simple apparatus some data of great value to dredging engineers has been obtained. In the first place, it has been ascertained that the area and form of the nozzle at the bottom of the suction pipe exercise considerable influence upon the percentage of sand in the flow through the pumps. For instance, it has proved that the nozzle should be completely imbedded in the sand as far as possible, as by this means it is possible to reduce the quantity of water drawn into the suction pipe. When in operation, the nozzle under suction causes a cavity around it in the bed of the river, and to obtain the highest efficiency the formation of such a cavity should be reduced to the minimum. Consequently, a new type of nozzle has been devised, by which it is always maintained in an imbedded position in the bed of the river, and the amount of water thus drawn in is insignificant. The utilization of this simple apparatus has resulted in several improvements being effected in the dredging machinery used by the Mersey dock board, with a corresponding increase in the efficiency of the plant and its operation.

## THE USE OF BRONZE CASTINGS FOR NAVAL PURPOSES.

By Dr. Alfred Gradenwitz.

Conning towers for submarine boats have recently been made from what is called "diamond bronze," being an alloy similar to Delta metal, Durana metal, etc., but for its considerably higher strength and tenacity and its freedom from any iron. In fact, the iron otherwise contained in alloys is a serious drawback to the safe handling of the compass. As on the other hand diamond bronze is extremely resistant against sea water, its use for naval purposes should seem to be highly suitable. It may be mentioned that tests made on a tower with cast-on rods showed a tensile strength of 45 kg. per sq. mm. (64,004 lb. per sq. in.) with 18 per cent elongation. The accompanying illustration represents some conning towers cast in the foundry of Messrs. Ostermann & Flüs, of Cologne-Riehl, Germany. The tower shown above is so large as to contain any checking apparatus for the propulsion, diving, and torpedo outfits, while affording accommodation for two or



BRONZE CONNING TOWERS FOR SUBMARINES IN THE CLEANING SHOP.

three men. On the tower will be seen the dome-shaped armored lookout cupola.

As regards the molding of these heavy bronze castings, the process is similar to that used in connection with iron castings, but for the fact that in the case of a bronze having a strength as high as 45 to 55 kilogrammes per square millimeter, with 18 per cent elongation, the crushing of a possible defective casting would cause quite unsurmountable difficulties. In fact, in order to allow of the metal being smelted anew, mechanical crushing would have to be resorted to.

As regards the molding material, a very permeable sand should be used, to enable the gases discharged during the casting to escape readily, avoiding the formation of any bubbles. The core of the conning tower is stamped simultaneously with the outer shell, and is provided with a larger coke bed in its interior, to allow of the air escaping readily also there. After a sufficient number of air channels have been provided on all sides of the mold, to allow of any gases and vapors formed being readily exhausted, the casings are lifted one after the other; any necessary retouching work is done and the mold blackened carefully, after which the whole mold, including the core, is carried to the drying furnace, to be dried there. After this operation has been carried out uniformly, the mold is assembled again carefully and is ready for casting.

The ingots should be given especial attention in the case of diamond bronze. The stronger a given material, the greater will the runners have to be, diamond bronze being comparable to steel castings from this point of view. In other words, this bronze calls for strong ingot funnels and pressure funnels, in case any conditions for successful work are to be secured. In preparing the ingots, a special point should be made of so designing their size and cross section that the mold in all its parts not only is filled up completely and infallibly with the liquid metal, but is so constructed that the ingots are able to yield a sufficient amount of liquid metal for liquation.

From the examples shown, it will be seen that the foundry art has, according to the above, made considerable advances also in the province of bronze castings, and it is thought probable that the scope of bronze castings will be greatly extended in future.

## SOME AMERICAN CONTRIBUTIONS TO TECHNICAL CHEMISTRY.[1]

By MARCUS BENJAMIN, Ph.D.

THE inventive genius of the American people is universally conceded. The necessity of accomplishing things quickly, incidental to the growth of a new country, such as ours, has naturally led to the invention of many forms of labor-saving machinery, and so with improved appliances have come improved methods. The technical chemist is, however, less fortunate than his brother in the professorial chair whose merits are made known by his students, thus attracting an ever-increasing following to his laboratory, and perhaps he is also less fortunate than his associate who devotes himself to research work; for to him are given medals and honorary memberships which are properly the "blue ribbons" of science; hence it is that the discoveries of the technical chemist, especially where they are commercially meritorious, remain too frequently unknown, and the profits of the improvement go to swell the dividends of the corporation to which he owes his allegiance while he receives no public recognition. It naturally follows, therefore, that any summary of the achievements in the development of technical chemistry must be very incomplete.

To say when chemistry begins is not generally possible, for its origin wanders back into alchemy and pharmacy on the one side and into physics on the other, and there are no sharp lines of separation among the various branches of science, for they gradually merge one into the other. In this country, however, we have grown to accept the date of the arrival of Joseph Priestley, June 4, 1794, as a most excellent time at which to begin the modern history of chemistry.

The younger Silliman's masterly "American Contributions to Chemistry"[2] gives me the right, therefore, to mention first Benjamin Thompson, Count Rumford (1751-1814),[3] whose studies in heat and fuel were as practical as they are important. His early knowledge of science was acquired from John Winthrop (1717-1779), who held the chair of mathematics and natural philosophy at Harvard from 1738 till his death. Of Count Rumford I have said elsewhere:[4] "He investigated the properties and management of heat, and the amount of it that was produced by the combustion of different kinds of fuel, by means of a calorimeter of his own invention." By reconstructing the fireplace he so improved the methods of warming apartments and cooking food that a saving of fuel of almost one-half was effected. He improved the construction of stoves, cooking ranges, coal grates, and chimneys, and showed that the non-conducting power of cloth is due to the air that is inclosed in its fibers. Silliman well says of him: "No writer of his time has left a nobler record of original power in physical science than Rumford." It will also be remembered that by will he provided funds "to teach by regular courses of academical and public lectures, accompanied by proper experiments, the utility of the physical and mathematical sciences for the improvement of the useful arts, and for the extension of the industry, prosperity, happiness, and well-being of society."[5] Let me also remind you that Wolcott Gibbs, the oldest and now the Nestor of American chemists, held the Rumford chair in the Lawrence Scientific School of Harvard from 1863 till 1888, during which time many of those who are now leaders in chemistry were students under him.

The last century was only a year old when Robert Hare (1781-1858) communicated his discovery of the oxyhydrogen blowpipe to the Chemical Society of Philadelphia. This instrument held a foremost place for the production of artificial heat until the recent introduction of the electric furnace. The application of the principle invented by Hare still finds extensive use for lighthouse illumination and similar purposes under the names of "Drumond light" and "calcium light." It is interesting to recall in this connection that Hare was the first to receive the Rumford medals from the Academy of Arts and Sciences.

Hare was also the inventor in 1816 of a calorimeter, a form of battery by which a large amount of heat was generated, and four years later he modified this apparatus, with which, then known as Hare's deflagrator, in 1823 he first demonstrated the volatilization and fusion of carbon. His memoir on the "Explosiveness of Niter," which was published by the Smithsonian Institution in 1850, was one of the earliest contributions by an American to the literature of explosives.[6]

The original discovery of chloroform is clearly of American origin and must be credited to Samuel Guthrie (1782-1848), of Sacketts Harbor, N. Y., whose researches anticipated those of Soubeiran, Liebig, and Dumas by nearly a year.

A committee of the Medico-chirurgical Society of Edinburgh gave him the credit for having first published an account of the therapeutic effects of chloroform as a diffusive stimulant. Dr. Guthrie was likewise the inventor of a process for the rapid conversion of potato starch into sugar. He also experimented with considerable boldness in the domain of explosives, inventing various fulminating compounds, which he developed commercially.[7]

It would be an ungracious task to discuss in this paper the much-controverted "ether discussion," but I may say, without fear of doing injustice to any of the several claimants for the honor of the discovery of this important anesthetic, that Charles Thomas Jackson (1805-1880), said to be one of the foremost chemists of his time in this country, claimed from experiments made by himself during the winter of 1841-2 in his own laboratory, that he obtained results showing "that a surgical operation could be performed on the patient under the full influence of sulphuric ether without giving him any pain." Four years later (in 1846) this was successfully accomplished by Dr. William T. G. Morton, who had studied chemistry in Dr. Jackson's laboratory. The French Academy of Sciences decreed one of the Montyon prizes to Jackson for his discovery of etherization, and one to Morton for his application of that discovery to surgical operations.[8]

Metallurgy is little more than the application of chemical knowledge to the extraction of metals from their ores, and I therefore beg to claim for the United States the first commercial production of steel. Zerah Colburn, the well-known engineer, gives William Kelly (1811-1888), an iron master of the Suwannee furnaces of Lyon County, Ky., the credit for the "first experiments in the conversion of melted cast iron into malleable steel by blowing air in jets through the mass in fusion." Later, when Sir Henry Bessemer made efforts to secure the patent of the process that bears his name, it was decided by the United States Patent Office that William Kelly was the first inventor and entitled to the patent, which was promptly issued to him. In 1871, when application was made for a renewal of the patents originally issued to Bessemer, Mushet, and Kelly, the last was successful, while the claims of the first were rejected.[9]

The successful electro-deposition of nickel and its commercial development are chiefly due to the energy of Isaac Adams (1836- ), a resident of Cambridge, Mass. He carefully studied the subject and found that the failure to obtain satisfactory results was caused by the presence of nitrates in the nickel solutions previously used. His invention gave rise to prolonged litigation, but in the end he was victorious. Dr. Chandler thus describes it in the following words: "The novel proposition was presented to the court, of a patent for not doing something, namely, for not permitting nitrates to find their way into the nickel solutions employed in nickel plating, and the court held that the exclusion of nitrates was an essential condition of successful nickel plating, and that a process involving this condition was just as patentable as a process involving any other special condition necessary for successful execution, and the patent was sustained."[10]

In passing I may mention the name of Joseph Wharton (1826- ), whose experiments in producing nickel in a pure and malleable condition so that it could be worked like iron culminated in the first production in 1865 of malleable nickel.

Chemistry owes a great debt of gratitude to the genius of Thomas Sterry Hunt (1826-1892) and one of his most notable contributions to technology is the permanent green ink which he invented in 1859 and which is used in the printing of our national bank notes and from the appearance of which the well-known term of "greenback" was derived. The Hunt and Douglas process for the precipitation of copper by iron, for a time so extensively used for the extraction of copper from low-grade ores, is an invention the credit of which he shares with the well-known metallurgist, James Douglas.

The vulcanization of India rubber by sulphur is the invention of Charles Goodyear (1800-60), who was so persistent in his efforts as to become an object of ridicule. Indeed, he was called an India rubber maniac and was described as a "man with an India rubber coat on, India rubber shoes, and in his pocket an India rubber purse, and not a cent in it." His invention consisted in mixing with the rubber a small quantity of sulphur, fashioning the articles from the plastic material and curing or vulcanizing the mixture by exposure to the temperature of 265-270 deg. F."[11]

Of almost equal importance was the invention of hard rubber or vulcanite, for which Nelson Goodyear (1811-57), a brother of Charles Goodyear, obtained a patent in 1851, claiming that the hard, stiff, inflexible compound could be best obtained by heating a mixture of rubber, sulphur, magnesia, etc., but this never became an article of commerce. In 1858 Austin Goodyear Day (1824-89) patented a mixture of two parts of rubber and one of sulphur, which, when heated to 275-300 deg. F., yielded the flexible and elastic product now generally known as hard rubber.[12]

Dr. Leander Bishop has said: "In the art of modifying the curious native properties of caoutchouc and gutta percha, and of molding their plastic elements into a thousand forms of beauty and utility, whether hard or soft, smooth or corrugated, rigid or elastic, American ingenuity and patient experiment have never been excelled."[13]

Exceedingly valuable to the industries of this country was the influence of James Curtis Booth (1810-88), who from 1849 till his death was melter and refiner in the United States mint. In 1836 he established a laboratory in Philadelphia for instruction in chemical analysis and chemistry applied to the arts, and in the course of a few years gathered around him nearly forty students, among whom were Martin H. Boyé, John F. Frazer, Thomas H. Garrett, Richard C. McCulloh and Campbell and Clarence Morfit, all of whom have achieved eminence as chemists. It was said of him, that "Mr. Booth had few, if any, superiors as a teacher of practical chemistry." From 1836 till 1845 he held the chair of chemistry applied to the arts in the Franklin Institute, delivering three courses of lectures extending over three years each. He was the author of an "Encyclopædia of Chemistry" (Philadelphia, 1850) and with Campbell Morfit of a report "On Recent Improvements in the Chemical Arts," published by the Smithsonian Institution in 1852. His appointment to the mint was coincident with the discovery of gold in California, and the new processes required to prepare the bullion for coinage were largely of his own invention and many of them, to use his own words, "were not known outside the mint."[14]

It is well known that prior to 1850 and for some time thereafter Philadelphia was the acknowledged center for the manufacture of chemicals for medicinal use. To collect the details of the many improved methods for the production of these chemicals would be a long and difficult task, and would require more space than I have at my command in this article. The names of such firms as Powers & Weightman and Rosengarten & Sons are readily recognized as those of manufacturers of standard chemicals. M. I. Wilbert has recently published a paper, entitled "Early Chemical Manufacturers: A Contribution to the History and Rise of the Development of Chemical Industries in America," to which I must refer you for further information concerning their growth and progress.[15]

I am reminded in this connection that the name of Edward Robinson Squibb (1819-1900) is one well worthy of deserved recognition among manufacturers of chemicals. The ether prepared by him by processes of his own invention has long been accepted as standard. For a brief period during the early fifties of the last century Dr. Squibb was associated with J. Lawrence Smith (1818-83) in Louisville, Ky., in the commercial production of chemical reagents and of the rarer pharmaceutical preparations.[16] It is also proper to add the name of the Baker & Adamson Chemical Company, of Easton, Pa., as that of a corporation which has established a reputation for the manufac-

[1] An address delivered before the Congress of Arts and Science, St. Louis, September, 1904.

[2] American Chemist, v., 1874, p. 70.

[3] See "Memoir of Sir Benjamin Thompson, Count Rumford, with Notices of his Daughter," by George E. Ellis, also "Complete Works of Count Rumford," 4 vols., published by the American Academy of Arts and Science (Boston, 1876).

[4] "Cyclopædia of American Biography," v., p. 345, article Rumford, Benjamin Thompson, Count.

[5] American Chemist, v., 1874, p. 73.

[6] "Smithsonian Miscellaneous Collections," ii., 1895. Also see the memoir of him by the elder Silliman in the American Journal of Science (2), xxvi., 1858, p. 100.

[7] An account of his career has been published in pamphlet form by his descendant, Ossian Guthrie.

[8] Dr. Jackson published a "Manual of Etherization with the History of this Discovery" (Boston, 1861) and much interesting information is to be had from a "Report of the House of Representatives of the United States of America, vindicating the rights of Charles T. Jackson on the Discovery of the Anesthetic Effect of Ether Vapor." The other side of the controversy is given in "The Discovery of Modern Anesthetics: By whom it was made?" by Laird W. Nevius, New York, 1894.

[9] Much has been written of the claims of Kelly and nearly all of the leading American metallurgists agree in conceding his priority. Swank and various writers in the Transactions of the American Institute of Mining Engineers may be consulted. Kelly's own story, as he gave it to the present writer, appears in the Iron Age, February 23, 1888, p. 339.

[10] Journal of the Society of Chemical Industry, xix., 1900, p. 611.

[11] His life has been published by Bradford K. Peirce with the title, "Trials of the Inventor," New York, 1860.

[12] American Chemist, ii., 1872, p. 330.

[13] "A History of American Manufacturers," by J. Leander Bishop (Philadelphia, 1860).

[14] A sketch of his career by Patterson du Bois was presented before the American Philosophical Society on October 5, 1888, and has since been issued as a separate of eight pages.

[15] Journal of the Franklin Institute, clvii., 1904, p. 365.

[16] See "Original Researches in Mineralogy and Chemistry," by J. Lawrence Smith (Louisville, Ky., 1884), p. xxxviii.

ture of pure chemicals by processes many of which are of their own devising. The success of this young firm is generally admitted to be due to Edward Hart (1854- ), who fills the chair of chemistry in Lafayette College.

Eben Norton Horsford (1818-93) made distinct contributions to technical chemistry and among these may be mentioned his invention of condensed milk. According to Charles L. Jackson, he originally prepared this most valuable article of food for use in Dr. Kane's Arctic expedition and afterward presented the process to one of his assistants, who then sold it to Gail Borden. His name, however, is more commonly associated with his invention of phosphatic yeast powder, the object of which is to return to the bread the phosphates lost in bolting the flour, and which, as is well known, form such an essential constituent of the food of animals. He also devised "a marvelously compact and light marching ration of compressed beef and parched wheat grits," which found some use at the time of the civil war, and his name is also attached to the preparation of "acid phosphate," so commonly used with summer beverages.[17]

The development of the mineral resources of our country has been due largely to those who from their knowledge of chemistry were able to recognize the commercial value of the natural deposits in the vicinity of their homes. This has been conspicuously the case with the great fertilizer industry of the South, and especially so in South Carolina, where the names of Charles Upham Shepard (1804-86) and St. Julien Ravenel (1819-82) are recognized as those of pioneers in that important branch of chemical industry.

To quote from Silliman again, and he is always an acceptable authority, "No observation or original research of Dr. Shepard has been fruitful of so much good in its consequences as his discovery of the deposits of phosphates of lime in the Eocene marl of South Carolina, and the distinct recognition of its great value for agriculture."[18] It was Dr. Ravenel, however, whose experiments made it possible to transform these phosphate rocks into commercial fertilizers, and of him the younger Shepard wrote in 1882: "Well might this community erect a public monument in honor of the man to whom pre-eminently is due the inauguration of that phosphate industry which has proven of such incalculable value to ourselves and others. As the statue of Berzelius adorns beautiful Stockholm, let us commemorate (similarly) the founder of Charleston's greatest industry." It may be added that Dr. Ravenel differed from the agricultural chemists of his time in devoting greater attention to the physiological phases of the application of fertilizers to plants than to the mere chemistry of the subject; this was naturally due to his early training in medicine.[19]

It would lead me too far from chemistry, perhaps, to discuss the work of the younger Shepard (1842- ) in successfully introducing tea culture into the United States, but his farm in Summerville, S. C., is a monument to the application of his chemical knowledge to a new industry, and well may his fellow-countrymen be proud of the results.

It is desirable to mention at this place the remarkable successes achieved by a small band of chemists who spent the four years of our civil war in their southland. George Washington Raines (1817-98), John le Conte (1818-91), Joseph le Conte (1823-91), and John William Mallett (1832- ) are among the more conspicuous names that occur to me. It was Raines who erected at Augusta, Ga., the Confederate powder works, which at the close of the war were regarded "as among the best in the world."[20]

The Confederate government appointed John le Conte to the superintendency of the extensive niter works established in Columbia, S. C., which place he retained during the war.[21] Joseph le Conte, a younger brother, served as chemist to the Confederate laboratory for the manufacture of medicines in 1862-3, and also in a similar capacity to the niter and mining bureau in 1864-5. Prof. Mallett was in charge of the ordnance bureau of the Confederate States, serving with the rank of colonel. He has described his experience under the title "Applied Chemistry in the South during the Civil War,"[22] which he has delivered as a lecture before various chemical societies.

A history of the manufacture of explosives in this country would carry us far into the past, for the oldest of the still existing powder mills was established in 1802 by Eleuthere Irene du Pont and the name of du Pont is still honorably associated with the industry, for so recently as 1893 two of that name received a patent for a smokeless powder which is now largely made at works near Wilmington, Del.

During the years 1862-4 Robert Ogden Doremus (1824- ) developed the use of compressed granulated gunpowder, which was adopted by the French government. It was concerning this inventor that Sir Frederick A. Abel in 1890 in his retiring address before the British Association said that Doremus "had proposed the employment in heavy guns of charges consisting of large pellets in prismatic form." Charles Edward Munroe (1848- ) must be recognized as the first in the world to prepare a "smokeless powder that consisted of a single substance in a state of chemical purity." This explosive, which he invented while chemist at the United States Torpedo Station, Rhode Island, and which became known as the "naval smokeless powder," was referred to by Secretary of War Tracy in 1892 as presenting "results considerably in advance of those hitherto obtained in foreign countries."[23]

Of later development is the Bernadou powder invented by John Baptiste Bernadou (1858- ), of the United States navy, and which it is claimed has been adopted for use in the naval branch of the service.

No contribution to the history of technical chemistry in the United States would be complete without some reference to the development of coal oil and petroleum. It seems almost impossible to realize that scarcely half a century ago the only use of petroleum was as a cure for rheumatism under the name of Seneca oil. The commercial exploitation of this important illuminant is, of course, largely due to the Standard Oil Company and to the expert chemists in their employ credit should be given for the production of the many beautiful by-products that are now made. A full description of these with proper reference to the chemist to whom we are indebted for them would, indeed, be valuable, but even for a simpler enumeration of the products in tabular form giving their immediate origin I must refer you to the text-books on industrial chemistry.[24]

One of the most interesting of these many compounds is vaseline, whose use in pharmacy is so prevalent. It was invented in 1870 by Robert Augustus Chesborough (1837- ). Charles Frederick Mabery (1850- ) has been an indefatigable worker in the theoretical branch of the subject, especially on the composition of petroleum, in the study of which he has been aided with grants from the C. M. Warren Fund for Chemical Research of the American Academy of Arts and Sciences. Stephen Farnam Peckham (1839- ) has been a prolific contributor to the literature of the technology of the subject and his report on petroleum, prepared for the tenth census (Washington, 1880) is standard authority. Another chemist who has studied petroleum both in his laboratory and also from a commercial point of view as well, is Samuel Philip Sadtler (1847- ). His "Industrial Organic Chemistry" (Philadelphia, 1900) gives a very satisfactory survey of the subject with an admirable bibliography. Among the younger men I learn that William Cathcart Day (1857- ) has succeeded by carrying out operations of distillation at the ordinary atmospheric pressure upon animal and vegetable matter, both separately and mixed, in obtaining three different materials, all of which present in different degrees the properties characteristic of asphalts.[25]

An early worker in the scientific part of this subject was Cyrus More Warren (1824-91), whose original researches on the volatile hydrocarbons and similar bodies resulted in many practical applications in the use of coal tar and asphalt, especially for roofing and paving purposes. Clifford Richardson (1856- ) has in recent years devoted much attention to the study of asphalt and is a recognized authority on its value for commercial purposes.

I cannot claim for the United States the invention of illuminating gas, although as early as 1823, its manufacture was begun in New York city, but the development of the production of a luminous water gas was largely accomplished in this country. According to excellent authority,[26] Thaddeus S. C. Lowe (1832- ) built and successfully conducted gas works in Phœnixville, Pa., in 1874, producing a water gas "far superior to that made from coal." According to Dr. Chandler there are forty or fifty different forms of apparatus for manufacturing water gas, but they are almost without exception applications of the invention of Thaddeus Lowe.[27]

Those of us whose memories extend back for a quarter of a century may recall Tessie de Motay (1819-80), whose agreeable personality charmed all of those who were so fortunate as to meet him, and to him is due the production of water gas in the late seventies of the last century by a process of his own invention in New York city.[28]

A much-needed substitute for ivory and horn that could be produced economically was invented in 1869 by John Wesley Hyatt (1837- ) and called by him celluloid. It is so seldom that foreign recognition is unqualifiedly given to our American inventors that I am glad of the opportunity to quote Thorpe,[29] who says, concerning celluloid, that it "is an intimate mixture of pyroxylin (guncotton or collodion) with camphor, first made by Hyatt, of Newark, U. S., and obtained by adding the pyroxylin to melted camphor . . . and evaporating to dryness." Its many applications in various industries are so well known as to need no further mention here.

It should not be forgotten that saccharin, a coal tar compound with a sweetening power of about five hundred times that of cane sugar, although now manufactured chiefly in Germany, was discovered in 1879 in the laboratory of the Johns Hopkins University by Constantin Fahlberg, a student under Ira Remsen (1846- ) and the Society of Chemical Industry in 1904 crowned Remsen's work by conferring upon him the medal of the society, recognizing thus for the first time in its history the discoveries of an American chemist.

In the domain of technical chemistry no American has ever achieved greater results than Hamilton Young Castner (1858-99), and the opportunity of presenting a brief summary of his brilliant inventions is a pleasure that I gladly welcome.

His first invention was a continuous process for the manufacture of bone charcoal, but this failed of commercial success, although scientifically of much interest, and he then turned his attention to the study of an improved method for the production of aluminium. To accomplish this it was necessary to produce sodium economically, and this he succeeded in doing by using carbide of iron as a reducing agent. When he began this now historic research the market price of aluminium was $10 a pound, and when his process was completed he was able to manufacture aluminium at about one dollar a pound. "This," says Dr. Chandler, "revolutionized the whole industry and aluminium could be now used for a hundred different purposes." In his retiring address before the British Association in 1890 Sir Frederick A. Abel said: "The success which has culminated in the admirable Castner process constitutes one of the most interesting of recent illustrations of the progress made in technical chemistry."

But there were other uses for which sodium could be employed, and so he invented a process for converting metallic sodium into sodium peroxide. Then came the suggestion that with cheap sodium pure cyanides could be produced, and so he modified his process so as to manufacture pure cyanides, especially the potassium and sodium cyanides, enormous quantities of which were used for the extraction of gold from low-grade ores. His active mind was ever busy with new solutions of chemical problems, and subsequent to the invention of electrolytic processes for the reduction of aluminium, Castner concentrated his attention on the original methods used by Sir Humphry Davy, and, overcoming the difficulties encountered by that great chemist, he soon devised an electric process of remarkable simplicity for obtaining metallic sodium from caustic soda by electrolysis. His ambition was not yet satisfied and he added to his triumphs a beautiful method for the electrolysis of common salt with the production of caustic soda and bleaching powder. Thus Castner invented "the first process which could be said to be a complete success for accomplishing what French, German, English and American chemists had been working at for a hundred years." Again to quote Chandler:[30] "He never worked on a chemical process that he did not invent a better one to accomplish the same result."

The silver metal and the white crystals, pure and beautiful, the results of his many hours of study and research, will always preserve in the literature of chemistry the memory of him of whom it is surely not too much to say that he was the most eminent of American inventors in chemical technology in recent times.

While Castner was studying the problem of preparing aluminium by chemical methods Charles Martin Hall (1863- ), a student in Oberlin College, conceived the plan of extracting aluminium by electrolysis and he found that a melted bath of the double fluorides of aluminium and metals more electro-positive than aluminium, such as sodium or calcium, was a perfect solvent for alumina, and from such a solution he was able to separate the aluminium by means of the electric current. It is by this process that all of the aluminium of commerce is produced to-day.

Moissan, whose extended researches with the electric furnace have made his name justly famous, writes: "The discovery of crystalline carbon silicide belongs to Acheson."[31] This remarkable abrasive, prepared by heating a mixture of silica, coke, alumina, and sodium chloride in an electric furnace, was invented in 1890 by Edward Goodrich Acheson (1856- ) while experimenting for the artificial production of diamonds, and is one of the many beautiful products obtained at Niagara Falls, where quite a number of chemical manufacturers have established their plants in order to take advantage of the power obtained from the great waterfall. Mr. Acheson has also succeeded in preparing artificial graphite as a by-product in the manufacture of the carborundum, and he claims that it is the result of the decomposition of the carbide formed in that process.[32]

Although the existence of calcium carbide has been recognized ever since its original production in 1857 by Edmund Davy, Wöhler, and Berthelot, it was not until May, 1892, that its commercial production became known in consequence of its chance discovery by Thomas Leopold Willson (1860- ) while experiment-

---

17 A sketch of his career prepared by Charles L. Jackson appeared in the Proceedings of the American Academy of Arts and Sciences, xxviii., 1903, p. 34.

18 American Chemist, v., 1874, p. 96.

19 Two memorial pamphlets of Dr. Ravenel have been published. One, entitled "In Memoriam, St. Julien Ravenel, M.D." (9 pp.), is a reprint of an editorial from the Charleston News and Courier of March 18, 1882. The other, entitled "Dr. St. Julien Ravenel," is a memorial published by the Agricultural Society of South Carolina, Charleston, S. C. (54 pp.).

20 He published in pamphlet form a "History of the Confederate Powder Works" (Augusta, 1882).

21 "Biographical Memoirs," National Academy of Sciences, iii., p. 369.

22 An abstract of this paper with the title "Industrial Chemistry in the South during the Civil War" is contained in the Scientific American for July 25, 1903.

23 The history of the "Development of Smokeless Powders" was the subject of Dr. Munroe's presidential address before the Washington Section of the American Chemical Society in 1896. See Journal of the American Chemical Society, xviii., 1896, p. 819.

24 See "A Handbook of Industrial Chemistry," by Samuel P. Sadtler (Philadelphia, 1900), p. 21.

25 Journal of the Franklin Institute, September 1899, p. 205.

26 See a "Communication on the Lowe Gas Process," New York (May, 1876) and "A Communication on the Lowe and Strong Gas Processes" of later date (probably 1878) and also "The Chemistry of Gas Lighting," by C. F. Chandler (Philadelphia, 1876), a reprint from the American Chemist for January and February, 1876. There is also a pamphlet report on the "History and Value of Water Gas Processes" (New York, 1864) by John Torrey and Carl Schultz which gives a brief summary of some sixty patents on the subject.

27 Journal of the Society of Chemical Industry, xix., 1900, p. 613, where also excellent descriptions of both the Lowe and the Motay processes are to be found.

28 See sketch of Cyprien M. Tessie de Motay by A. J. Rossi in the Journal of American Chemical Society, ii., 1880, p. 305.

29 "Dictionary of Applied Chemistry," i., 1891, p. 449.

30 See the "Unveiling of a Bronze Tablet in Havemeyer Hall to the Memory of Hamilton Young Castner, December 18, 1902," School of Mines Quarterly, xxv., January, 1904, p. 204.

31 "The Electric Furnace" (Easton, 1904), p. 273.

32 Journal of the Society of Chemical Industry, xix., 1900, p. 609.

ing in Spray, N. C. He obtained it by the fusion and reduction in an electric furnace of a mixture of finely powdered and intimately mixed lime and coke. When it comes in contact with water decomposition ensues with the production of acetylene gas, an illuminant of remarkable power. This valuable compound is also manufactured at Niagara Falls.

Another valuable application of the high temperatures obtained by the electric furnace to substances from which the extraction of the metal was formerly considered impossible is the method patented in November, 1903, by Frank Jerome Tone (1868- ), of Niagara Falls, N. Y., for obtaining metallic silicon by reducing silica with carbon in an electric furnace of his own construction.

Of great value is the elaborate bulletin[33] on "Chemicals and Allied Products" prepared for the twelfth census by Charles Edward Munroe, already mentioned, and Thomas Mareau Chatard (1848- ). The industries discussed are grouped into nineteen classes and with each the discussion is introduced by a history of the development of the manufacture in the United States, and at the close is a brief bibliography. The volume includes a digest of United States patents relating to the chemical industries.

Worthy of the most distinguished consideration is the career of Charles Frederick Chandler (1836- ). This eminent chemist has since 1864 taught the technical chemistry in the Schools of Science in Columbia University and no record of the development of chemistry applied to the arts in the United States would be complete without mention of his work. It is true that no great invention bears his name, but he has achieved results greater than inventions, for he has educated chemists, and yet even more than that, as we shall see. Go where you will and you will find busy workers in science who have learned from Chandler something of that splendid power of applying chemical methods to the subject at hand which has long since gained for him the reputation of being the foremost authority on technical chemistry in the United States. Wherever gold or silver is determined, the little assay ton weights—their conception was a stroke of genius—claim him as their inventor. The brilliant series of articles on technical chemistry—the best in the English language—that appeared in Johnson's Cyclopedia were written by him. The first museum of applied chemistry in the United States where the crude material may be studied in its course of development to a finished product was established by him. Masterly, indeed, are the practical contributions to chemistry which marked the years during which he had charge of the public health in New York city. It resulted in enormous benefits to the community, and in 1883 it was well said: "There is no other city in the world which has so complete a sanitary organization as New York"; for all of which credit is due to Chandler.[34] In 1899 he was chosen president of the Society of Chemical Industry, the first American upon whom that honor was conferred, and a year later, on June 18, 1900, in the lecture theater of the Royal Institution founded by Count Rumford, to whom reference has already been made, he delivered his presidential address on "Chemistry in America," in the course of which he elaborated most fully the achievements of those who have distinguished themselves in that branch of science in the United States.[35]

It is worth while, I think, to mention very briefly three branches of our national government that have had much to do with the development of chemical technology in this country. The first of these and also the oldest, for it celebrated its centenary in 1891, is the patent office,[36] where inventors receive the protection of the government for their discoveries. By thus recognizing worthy inventions a valuable stimulus is given to invention which has not been without value to the community. Of exceptional interest to chemists is the system of indexing chemical literature now in use in the classification division of the patent office.[37]

I will also call your attention to the excellent work done in the Division of Mineral Resources in the United States Geological Survey, where under the efficient direction of David Talbot Day (1859- ) valuable information and statistics are gathered concerning native minerals and ores from which are obtained the products of many leading chemical processes.[38]

Finally the bureau of chemistry of the Department of Agriculture has been a potent factor in the development of chemical industries. It was this bureau that first called the attention of the public to the possibility of establishing the beet sugar industry in the United States. As a result of the investigations carried on by chemists in this branch of the government service the average yield of cane sugar to the ton in the State of Louisiana has been increased from 130 pounds to 170 pounds. In the examination of road materials important contributions to technical chemistry have been made by this bureau. The valuable studies on the dietetic value of foods and on their adulterations, conducted under the direction of Dr. Harvey Washington Wiley (1847- ) have not only done much toward creating a demand for the enactment of national legislation for pure food, but they have also been praiseworthy contributions to the application of chemistry to sanitation. This bureau also should receive recognition for its fostering influence over the Association of Official Agricultural Chemists, an organization which has done so much to secure uniform methods of analysis of fertilizers and of foods.[39]

To Henry Carrington Bolton (1843-1903) is due the credit for the series of bibliographies of the literature of the chemical elements that have been published by the Smithsonian Institution. His own memory will always be worthily preserved by the splendid "Bibliography of Chemistry" in four octavo volumes, an important section of each of which is devoted to technical chemistry.

The records of the past give abundant hope for the future.

[33] Census Bulletin, No. 210. Quarto, 306 pp. Washington, June 25, 1902.

[34] See the sketch of Charles Frederick Chandler by the present writer in the Scientific American, lvii., July 16, 1887, p. 39, and "President Chandler and the New York City Health Department, 1866-1883," in the Sanitary Engineer, May 17, 1883.

[35] Journal of Society of Chemical Industry, xix., 1900, p. 591.

[36] Patent Centennial Celebration, 1891: Proceedings and Addresses," 554 pp. (Washington, 1892).

[37] See "On a System of Indexing Chemical Literature; Adopted by the Classification Division of the United States Patent Office," by E. C. Hill, Journal of the American Chemical Society, xxii., 1900, pp. 478-498; also Scientific American, lxxxvi., June 14, 1902, p. 411.

[38] Beginning with the year 1882, annual volumes of the Mineral Resources of the United States have been published.

[39] The literature issued by the Bureau of Chemistry is large and includes nearly one hundred important bulletins and many minor circulars and leaflets.

## THE CONSTRUCTION OF A SILVERED GLASS TELESCOPE, FIFTEEN AND A HALF INCHES IN APERTURE, AND ITS USE IN CELESTIAL PHOTOGRAPHY.—I.

By HENRY DRAPER, M.D., Professor of Natural Science in the University of New York.*

THE construction of a reflecting telescope capable of showing every celestial object now known, is not a very difficult task. It demands principally perseverance and careful observation of minutiæ. The cost of materials is but trifling compared with the result obtained, and I can see no reason why silvered glass instruments should not come into general use among amateurs. The future hopes of astronomy lie in the multitude of observers, and in the concentration of the action of many minds. If what is written here should aid in the advance of that noble study, I shall feel amply repaid for my labor.

A short historical sketch of this telescope may not be uninteresting. In the summer of 1857, I visited Lord Rosse's great reflector, at Parsonstown, and, in addition to an inspection of the machinery for grinding and polishing, had an opportunity of seeing several celestial objects through it. On returning home, in 1858, I determined to construct a similar, though smaller instrument, which, however, should be larger than any other in America, and be especially adapted for photography. Accordingly, in September of that year, a 15-inch speculum was cast, and a machine to work it made. In 1860, the observatory was built, by the village carpenter, from my own designs, at my father's country seat, and the telescope with its metal speculum mounted. This latter was, however, soon

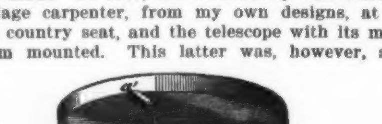


FIG. 1.—THE SILVERING VESSEL.

after abandoned, and silvered glass adopted. During 1861, the difficulties of grinding and polishing that are detailed in this account were met with, and the remedies for many of them ascertained. The experiments were conducted by the aid of three 15½-inch disks of glass, together with a variety of smaller pieces. Three mirrors of the same focal length and aperture are almost essential, for it not infrequently happens that two in succession will be so similar that a third is required for attempting an advance beyond them. One of these was made to acquire a parabolic figure, and bore a power of 1,000. The winter was devoted to perfecting the art of silvering, and to the study of special photographic processes. A large portion of 1862 was spent with a regiment in a campaign in Virginia, and but few photographs were produced till autumn, when sand clocks and clepsydras of several kinds having been made, the driving mechanism attained great excellence. During the winter the art of local corrections was acquired, and two 15½-inch mirrors, as well as two of 9 inches for the photographic enlarging apparatus, were completed. The greater part of 1863 has been occupied by lunar and planetary photography, and the enlargement of the small negatives obtained at the focus of the great reflector. Lunar negatives have been produced which have been magnified to 3 feet in diameter. I have also finished two mirrors 15½ inches in aperture, suitable for a Herschelian telescope, that is, which can only converge oblique pencils to a focus free from aberration. This work has all been accomplished in the intervals of professional labor.

The details of the preceding operations are arranged as follows: § 1. Grinding and Polishing the Mirrors; § 2. The Telescope Mounting; § 3. The Clock Movement; § 4. The Observatory; § 5. The Photographic Laboratory; §6. The Photographic Enlarger.

### §1. GRINDING AND POLISHING THE MIRRORS.

#### (1.) *Experiments on a Metal Speculum.*

My first 15-inch speculum was an alloy of copper and tin, in the proportions given by Lord Rosse. His general directions were closely followed, and the casting was very fine, free from pores, and of silvery whiteness. It was 2 inches thick, weighed 110 pounds, and was intended to be of 12 feet focal length. The grinding and polishing were conducted with the Rosse machine. Although a great amount of time was spent in various trials, extending over more than a year, a fine figure was never obtained—the principal obstacle to success being a tendency to polish in rings of different focal length. It must, however, be borne in mind that Lord Rosse had so thoroughly mastered the peculiarities of his machine as to produce with it the largest specula ever made and of very fine figure.

* Reprinted from Smithsonian Contributions to Knowledge, Vol. xxxiv.

During these experiments there was occasion to grind out some imperfections, 8/100 of an inch deep, from the face of the metal. This operation was greatly assisted by stopping up the defects with a thick alcoholic solution of Canada balsam, and having made a rim of wax around the edge of the mirror, pouring on nitro-hydrochloric acid, which quickly corroded away the uncovered spaces. Subsequently an increase in focal length of 15 inches was accomplished, by attacking the edge zones of the surface with the acid in graduated depths.

An attempt also was made to assist the tedious grinding operation by including the grinder and mirror in a Voltaic circuit, making the speculum the positive

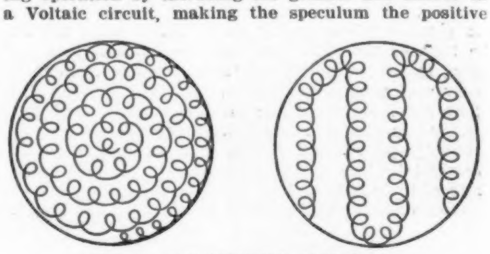


FIG. 2.—POLISHING STROKES.

pole. By decomposing acidulated water between it and the grinder, and thereby oxidizing the tin and copper of the speculum, the operation was much facilitated, but the battery surface required was too great for common use. If a sufficient intensity was given to the current, speculum metal was transferred without oxidation to the grinder, and deposited in thin layers upon it. It was proposed at one time to make use of this fact, and coat a mirror of brass with a layer of speculum metal by electrotyping. The gain in lightness would be considerable.

During the winter of 1860 the speculum was split into two pieces by the expansion in freezing of a few drops of water that had found their way into the supporting case.

#### (2.) *Silvering Glass.*

At Sir John Herschel's suggestion (given on the occasion of a visit that my father paid him in 1860), experiments were next commenced with silvered glass specula. These were described as possessing great capabilities for astronomical purposes. They reflect more than 90 per cent of the light that falls upon them, and only weigh one-eighth as much as specula of metal of equal aperture.

As no details of Steinheil's or Foucault's processes for silvering in the cold way were accessible at the time, trials extending at intervals over four months were made. A variety of reducing agents were used, and eventually good results obtained with milk sugar.

Soon after a description of the process resorted to by M. Foucault in his excellent experiments was procured. It consists in decomposing an alcoholic solution of ammonia and nitrate of silver by oil of cloves. The preparation of the solutions and putting them in a proper state of instability are very difficult, and the results by no means certain. The silver is apt to be soft and easily rubbed off, or of a leaden appearance. It is liable to become spotted from adherent particles of the solutions used in its preparation, and often when dissolved off a piece of glass with nitric acid leaves a reddish powder. Occasionally, however, the process gives excellent results.

In the winter of 1861, M. Cimeg published his method of silvering looking-glasses by tartrate of potash and soda (Rochelle salt). Since I have made modifications in it fitting the silver for being polished on the reverse side, I have never on any occasion failed to secure bright, hard, and in every respect perfect films.

The operation, which in many details resembles that

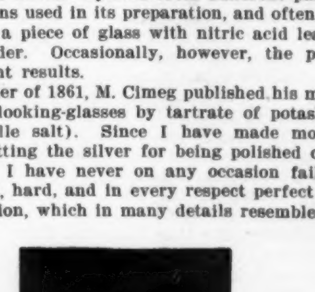


FIG. 3.—EFFECT OF PRESSURE ON A REFLECTING SURFACE.

of M. Foucault, is divided into: 1, cleaning the glass; 2, preparing the solutions; 3, warming the glass; 4, immersion in the silver solution and stay there; 5, polishing. It should be carried on in a room warmed to 70 deg. F. at least. The description is for a 15½-inch mirror.

1. Clean the glass like a plate for collodion photography. Rub it thoroughly with nitric acid, and then wash it well in plenty of water, and set it on edge on filtering paper to dry. Then cover it with a mixture of alcohol and prepared chalk, and allow evaporation to take place. Rub it in succession with many pieces of cotton flannel. This leaves the surface almost chemically clean. Lately, instead of chalk I have used plain uniodized collodion, and polished with a freshly washed piece of cotton flannel, as soon as the film had become semi-solid.

2. Dissolve 560 grains of Rochelle salt in two or three ounces of water and filter. Dissolve 800 grains

of nitrate of silver in four ounces of water. Take an ounce of strong ammonia of commerce, and add nitrate solution to it until a brown precipitate remains undissolved. Then add more ammonia and again nitrate of silver solution. This alternate addition is to be carefully continued until the silver solution is exhausted, when some of the brown precipitate should remain in suspension. The mixture then contains an undissolved excess of oxide of silver. Filter. Just before using, mix with the Rochelle salt solution, and add water enough to make 22 ounces.

The vessel in which the silvering is to be performed may be a circular dish (Fig. 1) of ordinary tinplate, 16½ inches in diameter, with a flat bottom and perpendicular sides one inch high, and coated inside with a mixture of beeswax and rosin (equal parts). At opposite ends of one diameter two narrow pieces of wood, *a a'*, ⅛ of an inch thick, are cemented. They are to keep the face of the mirror from the bottom of the vessel, and permit of a rocking motion being given to the glass. Before using such a vessel, it is necessary to touch any cracks that may have formed in the wax with a hot poker. A spirit lamp causes bubbles and holes through to the tin. The vessel, too, must always, especially if partly silvered, be cleaned with nitric acid and water, and left filled with cold water till needed. Instead of the above, India rubber baths have been occasionally used.

3. In order to secure fine and hard deposits in the shortest time and with weak solutions, it is desirable, though not necessary, to warm the glass slightly. This is best done by putting it in a tub or other suitably sized vessel, and pouring in water enough to cover the glass. Then hot water is gradually stirred in, till the mixture reaches 100 deg. F. It is also advantageous to place the vessels containing the ingredients for the silvering solution in the same bath for a short time.

4. On taking the glass out of the warm water, carry it to the silvering vessel—into which an assistant has just previously poured the mixed silvering solution—and immediately immerse it face downward, dipping in first one edge and then quickly letting down the other till the face is horizontal. The back, of course, is not covered with the fluid. The same precautions are necessary to avoid streaks in silvering as in the case of putting a collodion plate in the bath. Place the whole apparatus before a window. Keep up a slow rocking motion of the glass, and watch for the appearance of the bright silver film. The solution quickly turns brown, and the silver soon after disappears, usually in from three to five minutes. Leave the mirror in the liquid about six times as long. At the expiration of the twenty minutes or half hour lift it out, and look through it at some very bright object. If the object is scarcely visible, the silver surface must then be washed with plenty of water, and set on edge on bibulous paper to dry. If, on the contrary, it is too thin, put it quickly back, and leave it until thick enough. When polished the silver ought, if held between the eye and the sun, to show his disk of a light blue tint. On coming out of the bath the metallic surface should have a rosy golden color by reflected light.

5. When the mirror is thoroughly dry, and no drops of water remain about the edges, lay it upon its back on a thoroughly dusted table. Take a piece of the softest thin buckskin, and stuff it loosely with cotton to make a rubber. Avoid using the edge pieces of a skin, as they are always hard and contain nodules of lime.

Go gently over the whole silver surface with this rubber in circular strokes, in order to commence the removal of the rosy golden film, and to condense the silver. Then having put some very fine rouge on a piece of buckskin laid flat on the table, impregnate the rubber with it. The best stroke for polishing is a motion in small circles, at times going gradually round on the mirror, at times across on the various chords (Fig. 2). At the end of an hour of continuous gentle rubbing, with occasional touches on the flat rouged skin, the surface will be polished so as to be perfectly black in oblique positions, and with even moderate care, scratchless. The process is like a burnishing. Put the rubber carefully away for another occasion.

The thickness of the silver thus deposited is about 1/200,000 of an inch. Gold leaf, when equally transparent, is estimated at the same fraction. The actual value of the amount on a 15½-inch mirror is not quite a cent—the weight being less than 4 grains (239 milligrammes on one occasion when the silver was unusually thick), if the directions above given are followed.

Variations in thickness of this film of silver on various parts of the face of the mirror are consequently only small fractions of 1/200,000 of an inch, and are therefore of no optical moment whatever. If a glass has been properly silvered, and shows the sun of the same color and intensity through all parts of its surface, the most delicate optical tests will certainly fail to indicate any difference in figure between the silver and the glass underneath. The faintest peculiarities of local surface seen on the glass by the method of M. Foucault, will be reproduced on the silver.

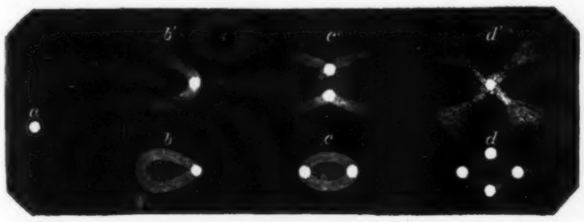



FIG. 4.—EFFECTS OF HEAT ON A REFLECTING SURFACE.

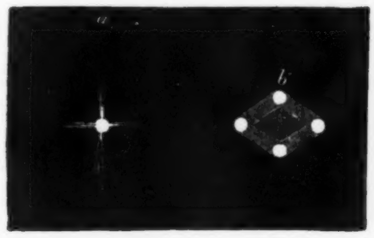



FIG. 5.—EFFECTS OF HEAT RENDERED PERMANENT.

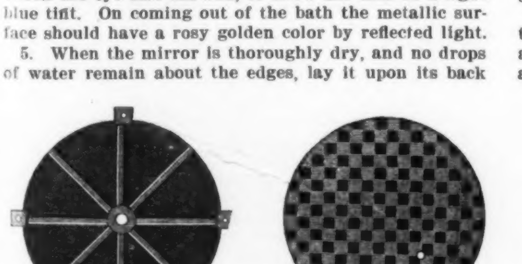
The durability of these silver films varies, depending on the circumstances under which they are placed, and the method of preparation. Sulphureted hydrogen tarnishes them quickly. Drops of water may split the silver off. Under certain circumstances, too, minute fissures will spread all over the surface of the silver, and it will apparently lose its adhesion to the glass. This phenomenon seems to be connected with a continued exposure to dampness, and is avoided by grinding the edge of the concave mirror flat, and keeping it covered when not in use with a sheet of flat plate glass. Heat seems to have no prejudicial effect, though it might have been supposed that the difference in expansibility would have overcome the mutual adhesion.

Generally silvered mirrors are very enduring, and will bear polishing repeatedly, if previously dried by heat. I have some which have been used as diagonal reflectors in the Newtonian, and have been exposed during a large part of the day to the heat of the sun concentrated by the 15½-inch mirror. These small mirrors are never covered, and yet the one now in the telescope has been there a year, and has had the dusty film—like that which accumulates on glass—polished off it a dozen times.

In order to guard against tarnishing, experiments were at first made in gilding silver films, but were abandoned when found to be unnecessary. A partial conversion of the silver film into a golden one, when it will resist sulphureted hydrogen, can be accomplished as follows: Take three grains of hyposulphite of soda, and dissolve it in an ounce of water. Add to it slowly a solution in water of one grain of chloride of gold. A lemon yellow liquid results, which eventually becomes clear. Immerse the silvered glass in it for twenty-four hours. An exchange will take place, and the film become yellowish. I have a piece of glass prepared in this way which remains unhurt in a box, where other pieces of plain silvered glass have changed some to yellow, some to blue, from exposure to coal gas.

I have also used silvered glass plates for daguerreotyping. They iodize beautifully if freshly polished, and owing probably to the absence of the usual copper alloy of silver plating, take impressions with very short exposures. The resulting picture has a rosy warmth, rarely seen in ordinary daguerreotypes. The only precaution necessary is in fixing to use an alcoholic solution of cyanide of potassium, instead of hyposulphite of soda dissolved in water. The latter has a tendency to split up the silver. The subsequent washing must be with diluted common alcohol.

Pictures obtained by this method will bear high magnifying powers without showing granulation. Unfortunately the exposure required for them in the telescope is six times as great as for a sensitive wet collodion, though the iodizing be carried to a lemon yellow, the bromizing to a rose red, and the plate be returned to the iodine.



*a* *b*

FIG. 6.—THE IRON GRINDER.

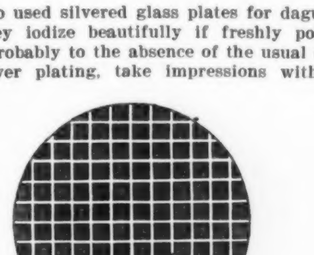


FIG. 7.—THE POLISHING TOOL.

### (3.) *Grinding and Polishing Glass.*

Some of the facts stated in the following paragraphs, the result of numerous experiments, may not be new to practical opticians. I have had, however, to polish with my own hands more than a hundred mirrors of various sizes, from 19 inches to ¼ of an inch in diameter, and to experience very frequent failures for three years, before succeeding in producing large surfaces with certainty and quickly. It is well nigh impossible to obtain from opticians the practical minutiæ which are essential, and which they conceal even from each other. The long-continued researches of Lord Rosse, Mr. Lassell, and M. Foucault are full of the most valuable facts, and have been of continual use.

The subject is divided into: a. The Peculiarities of Glass; b. Emery and Rouge; c. Tools of Iron, Lead, and Pitch; d. Methods of Examining Surfaces; e. Machines.

#### a. Peculiarities of Glass.

Effects of Pressure.—It is generally supposed that glass is possessed of the power of resistance to compression and rigidity in a very marked manner. In the course of these experiments it has appeared that a sheet of it, even when very thick, can with difficulty be set on edge without bending so much as to be optically worthless. Fortunately, in every disk of glass that I have tried, there is one diameter on either end of which it may stand without harm.

In examining lately various works on astronomy and optics, it appears that the same difficulty has been found not only in glass but also in speculum metal. Short used always to mark on the edge of the large mirrors of his Gregorian telescopes the point which should be placed uppermost, in case they were removed from their cells. In achromatics the image is very sensibly changed in sharpness if the flint and crown are not in the best positions; and Mr. Airy, in mounting the Northumberland telescope, had to arrange the means for turning the lenses on their common axis, until the finest image was attained. In no account, however, have I found a critical statement of the exact nature of the deformation, the observers merely remarking that in some positions of the object glass there was a sharper image than in others.

Before I appreciated the facts now to be mentioned, many fine mirrors were condemned to be repolished, which, had they been properly set in the mountings, would have operated excellently.

In attempting to ascertain the nature of deformations by pressure, many changes were made in the position of the disk of glass, and in the kind of support. Some square mirrors, too, were ground and polished. As an example of the final results, the following case is presented: A 15½-inch unsilvered mirror 1¾ inch thick was set with its best diameter perpendicular, the axis of the mirror being horizontal (Fig. 8). The image of a pin-hole illuminated by a lamp was then observed to be single, sharply defined, and with interference rings surrounding it as at *a*, Fig. 3. On turning the glass 90 degrees, that is, one quarter way around, its axis still pointing in the same direction, it could hardly be realized that the same concave surface was converging the rays. The image was separated into two of about equal intensity, as at *b*, with a wing of light going out above and below from the junction. Inside and outside of the focal plane the cone of rays had an elliptical section, the major axis being horizontal inside, and perpendicular outside. Turning the mirror still more round the image gradually improved, until the original diameter was perpendicular again—the end that had been the uppermost now being the lowest. A similar series of changes occurred in supporting the glass on various parts of the other semicircle. It might be supposed that irregularities on the edge of the glass disk, or in the supporting arc would account for the phenomena. But two facts dispose of the former of these hypotheses: in the first place if the glass be turned exactly half way round, the character of the image is unchanged, and it is not to be believed that in many different mirrors this could occur by chance coincidence. In the second place, one of these mirrors has been carefully examined after being ground and polished three times in succession, and on each occasion required the same diameter to be perpendicular. As to the second hypothesis no material difference is observed whether the supporting arc below be large or small, nor when it is replaced by a thin semicircle of tinplate lined with cotton wool.

I am led to believe that this peculiarity results from the structural arrangement of the glass. The specimens that have served for these experiments have probably been subjected to a rolling operation when in a plastic state, in order to be reduced to a uniform thickness. Optical glass, which may be made by softening down irregular fragments into molds at a temperature below that of fusion, may have the same difficulty, but whether it has a diameter of minimum compression can only be determined by experiment. Why speculum metal should have the same property might be ascertained by a critical examination of the process for casting, and the effect of the position of the openings in the mold for the entrance of the molten metal.

Effects of Heat.—The preceding changes in glass when isolated appear very simple, and their remedy, to keep the proper diameter perpendicular, is so obvious that it may seem surprising that they should have given origin to any embarrassment. In fact it is now desirable to have a disk in which they are well marked. But in practice they are complicated in the most trying manner with variations produced by heat pervading the various parts of the glass unequally. The following case illustrates the effects of heat:

A 15½-inch mirror, which was giving at its center of curvature a very fine image (*a*, Fig. 4) of an illuminated pin-hole, was heated at the edge by placing the

right hand on the back of the mirror, at one end of the horizontal diameter. In a few seconds an arc of light came out from the image as at *b'*, and on putting the left hand on the other extremity of the same diameter the appearance *c'* was that of two arcs of light crossing each other, and having an image at each intersection. The mirror did not recover its original condition in ten minutes. Another person on a subsequent occasion touching the ends of the perpendicular diameter at the same time that the horizontal were warmed, caused the image *d'* to become somewhat like two of *c'*, put at right angles to each other. A little distance outside the focus the complementary appearances, *b*, *c*, *d*, were found.

By unsymmetrical warming still more remarkable forms emerged in succession, some of which were more like certain nebulæ with their milky light, than any regular geometrical figure.

If the glass had, after one of these experiments, been immediately put on the polishing machine and re-polished, the changes in surface would to a certain extent have become permanent, as in Chinese specula, and the mirror would have required either re-grinding or prolonged polishing to get rid of them. This occurred unfortunately very frequently in the earlier stages of this series of experiments, and gave origin on one occasion to a surface which could only show the image of a pin-hole as a lozenge (*b*, Fig. 5), with an image at each angle inside the focus, and as an image *a* with four wings outside.

But it must not be supposed that such apparent causes as these are required to disturb a surface injuriously. Frequently mirrors in the process for correction of spherical aberration will change the quality of their images without any perceptible reason for the alteration. A current of cold or warm air, a gleam of sunlight, the close approach of some person, an unguarded touch, the application of cold water injudiciously will ruin the labor of days. The avoidance of these and similar causes requires personal experience, and the amateur can only be advised to use too much caution rather than too little.

Such accidents, too, teach a useful lesson in the management of a large telescope, never, for instance, to leave one-half the mirror or lens exposed to radiate into cold space, while the other half is covered by a comparatively warm dome. Under the head of the Sun-Camera, some further facts of this kind may be found.

Oblique Mirrors.—Still another propensity of glass and speculum metal must be noted. A truly spherical concave can only give an image free from distortion when it is so set that its optical axis points to the object and returns the image directly back toward it. But I have polished a large number of mirrors in which an image free from distortion was produced *only* when oblique pencils fell on the mirror, and the image was returned along a line forming an angle of from 2 to 3 degrees with the direction of the object. Such mirrors, though exactly suited for the Herschelian construction, will not officiate in a Newtonian unless the diagonal mirror be put enough out of center in the tube, to compensate for the figure of the mirror. Some of the best photographs of the moon that have been produced in the observatory, were made when the diagonal mirror was 6 inches out of center in the 16-inch tube. Of course the large mirror below was not perpendicular to the axis of the tube, but was inclined 2 deg. 32 min. The figure of such a concave might be explained by the supposition that it was as if cut out of a parabolic surface of twice the diameter, so that the vertex should be on the edge. But if the mirror was turned 180 deg. it apparently did just as well as in the first position, the image of a round object being neither oval nor elliptical, and without wings. The image, however, is never quite as fine as in the usual kind of mirrors. The true explanation seems rather to be that the radius of curvature is greater along one of the diameters than along that at right angles. How it is possible for such a figure to arise during grinding and polishing is not easy to understand, unless it be granted that glass yields more to heat and compression in one direction than another.

After these facts had been laboriously ascertained, and the method of using such otherwise valueless mirrors put in practice as above stated, chance brought a letter of Maskelyne to my notice. He says, "I hit upon an extraordinary experiment which greatly improved the performance of the six-feet reflector." It was one made by Short. "As a like management may improve many other telescopes, I shall here relate it: I removed the great speculum from the position it ought to hold perpendicular to the axis of the tube when the telescope is said to be rightly adjusted, to one a little inclined to the same and found a certain inclination of about 2½ deg. (as I found by the alteration of objects in the finer one of Dollond's best night glasses with a field of 6 deg.), which caused the telescope to show the object (a printed paper) incomparably better than before; insomuch that I could read many of the words which before I could make nothing at all of. It is plain, therefore, that this telescope shows best with a certain oblique pencil of rays. Probably it will be found that this circumstance is by no means peculiar to this telescope." This very valuable observation has lain buried for eighty-two years, and ignorance of it has led to the destruction of many a valuable surface.

As regards the method of combating this tendency, it is as a general rule best to re-grind or rather re-fine the surface, for though pitch polishing has occasionally corrected it in a few minutes, it will not always do so. I have polished a surface for thirteen and a half hours, examining it frequently, without changing the obliquity in the slightest degree.

Glass, then, is a substance prone to change by heat and compression, and requiring to be handled with the utmost caution.

b. Emery and Rouge.

In order to excavate the concave depression in a piece of glass, emery as coarse as the head of a pin has been commonly used. This cuts rapidly, and is succeeded by finer grained varieties, till flour emery is reached. After that only washed emeries should be permitted. They are made by an elutriating process invented by Dr. Green.

Five pounds of the finest sifted flour emery are mixed with an ounce of pulverized gum arabic. Enough water to make the mass like treacle is then added, and the ingredients are thoroughly incorporated by the hand. They are put into a deep jar containing a gallon of water. After being stirred the fluid is allowed to come to rest, and the surface is skimmed. At the end of an hour the liquid containing extremely fine emery in suspension is decanted or drawn off with a siphon, nearly down to the level of the precipitated emery at the bottom, and set aside to subside in a tall vessel. When this has occurred, which will be in the lapse of a few hours, the fluid is to be carefully poured back into the first vessel, and the fine deposit in the second put into a stoppered bottle. In the same way by stirring up the precipitate again, emery that has been suspended 30, 10, 3, 1 minutes, and 20, 3 seconds is to be secured and preserved in wide-mouthed vessels.

The quantity of the finer emeries consumed in smoothing a 15½-inch surface is very trifling—a mass of each as large as two peas sufficing.

Rouge, or peroxide of iron, is better bought than prepared by the amateur. It is made by calcining sulphate of iron and washing the product in water. Three kinds are usually found in commerce: a very coarse variety containing the largest percentage of the cutting black oxide of iron, which will scratch glass like quartz; a very fine variety which can hardly polish glass, but is suitable for silver films; and one intermediate. Trial of several boxes is the best method of procuring that which is desired.

c. Tools of Iron, Lead, and Pitch.

In making a mirror, one of the first steps is to describe upon two stout sheets of brass or iron, arcs of a circle with a radius equal to twice the desired focal length, and to secure, by filing and grinding them together, a concave and convex gage. When the radius bar is very long, it may be hung against the side of a house. By the assistance of these templets, the convex tools of lead and iron and the concave surface of the mirror are made parts of a sphere of proper diameter.

The excavation of a large flat disk of glass to a concave is best accomplished by means of a thick plate of lead, cast considerably more convex than the gage. The central parts wear away very quickly, and when they become too flat must be made convex again by striking the lead on the back with a hammer. The glass is thus caused gradually to approach the right concavity. Ten or twelve hours usually suffice to complete this stage. The progress of the excavating is tested sufficiently well by setting the convex gage on a diameter of the mirror, and observing how many slips of paper of a definite thickness will pass under the center or edge, as the case may be. This avoids the necessity of a spherometer. The thickness of paper is found correctly enough by measuring a half ream, and dividing by the number of sheets. In this manner differences in the versed sine of a thousandth of an inch may be appreciated, and a close enough approximation to the desired focal length reached—the precision required in achromatics not being needed. The preparation of the iron tools on which the grinding is to be finished is very laborious where personal exertion is used. They require to be cast thin in order that they may be easily handled, and hence cannot be turned with very great exactness.

The pair for my large mirrors are 15½ inches in diameter, and were cast ⅜ of an inch thick, being strengthened however on the back by eight ribs ¾ of an inch high, radiating from a solid center two inches in diameter (*a*, Fig. 6). They weighed 25 pounds apiece. Four ears, with a tapped hole in each, project at equal distances round the edge, and serve either as a means of attachment for a counterpoise lever, or as handles.

After these were turned and taken off the lathe chuck, they were found to be somewhat sprung, and had to be scraped and ground in the machine for a week before fitting properly. The slowness in grinding results from the emery becoming imbedded in the iron, and forming a surface as hard as adamant.

Once acquired, such grinders are very valuable, as they keep their focal length and figure apparently without change if carefully used, and only worked on glass of nearly similar curvature. At first no grooves were cut upon the face, for in the lead previously employed for fining they were found to be a fruitful source of scratches, on account of grains of emery imbedding in them, and gradually breaking loose as the lead wore away. Subsequently it appeared that unless there was some means of spreading water and the grinding powders evenly, rings were likely to be produced on the mirror, and the iron was consequently treated as follows:

A number of pieces of wax, such as is used in making artificial flowers, were procured. The convex iron was laid out in squares of ¾ of an inch on the side, and each alternate one being touched with a thick alcoholic solution of Canada balsam, a piece of wax of that size was put over it. This was found after many trials to be the best method of protecting some squares, and yet leaving others in the most suitable condition to be attacked. A rim of wax, melted with Canada balsam, was raised around the edge of the iron, and a pint of aqua regia poured in. In a short time this corroded out the uncovered parts to a sufficient depth, leaving an appearance like a chess-board, except that the projecting squares did not touch at the adjoining angles (*b*, Fig. 6). I should have chipped the cavities out, instead of dissolving them away, but for fear of changing the radius of curvature and breaking the thin plate. However as soon as the iron was cleaned, it proved to have become flatter, the radius of curvature having increased 7¾ inches. This shows what a state of tension and compression there must be in such a mass, when the removal of a film of metal 1-50 of an inch thick, here and there, from one surface, causes so great a change.

When the glass has been brought to the finest possible grain on such a grinder, a polishing tool has to be prepared by covering the convex iron with either pitch or rosin. These substances have very similar properties, but the rosin by being clear affords an opportunity of seeing whether there are impurities, and therefore has been frequently used, straining being unnecessary. It is, however, too hard as it occurs in commerce, and requires to be softened with turpentine.

A mass sufficiently large to cover the iron ¼ of an inch thick is melted in a porcelain or metal capsule by a spirit lamp. When thoroughly liquid the lamp is blown out, and spirits of turpentine added, a drachm or two at a time. After each addition a chisel or some similar piece of metal is dipped into the fluid rosin, and then immersed in water at the temperature of the room. After a minute or two it is taken out, and tried with the thumb-nail. When the proper degree of softness is obtained, an indentation can be made by a moderate pressure.

The iron having been heated in hot water is then painted in stripes ¼ of an inch deep with this resinous composition. The glass concave to be polished being smeared with rouge, is pressed upon it to secure a fit, and the iron is then put in cold water. With a narrow chisel straight grooves are made, dividing the surface into squares of one inch, separated by intervals of one-quarter of an inch (Fig. 7). Under certain circumstances it is also desirable to take off every other square, or perhaps reduce the polishing surface irregularly here and there, to get an excess of action on some particular portion of the mirror.

It is well, on commencing to polish with a tool made in this way, to warm the glass as well as the tool in water before bringing the two in contact. If this is not done the polishing will not go on kindly, a good adaptation not being secured for a length of time, and the glass surface being injured at the outset. The rosin on a polisher put away for a day or two suffers an internal change, a species of irregular swelling, and does not retain its original form. Heating, too, has a good effect in preventing disturbance by local variations of temperature in the glass.

The description of "Local Polishers" will be given under Machines.

(To be continued.)

## THE CONSTITUENTS OF GUTTA-PERCHA.*

By A. TSCHIRCH and O. MÜLLER.

NEW GUINEA and Sumatra gutta-perchas have been examined, and new substances have been isolated in a pure and crystalline condition that have necessitated the introduction of new terminology. The authors retain the terms gutta, alban, fluavil and albanan, but employ them in a generic sense; the albans are soluble in boiling alcohol, the fluavils in cold, and the albanans in neither cold nor hot.

New Guinea gutta-percha is obtained from *Palaquium supflanum*. It is almost entirely soluble in cold benzene, chloroform, carbon disulphide, and toluene, as well as in boiling ether and petroleum spirit. Repeated boiling with alcohol yielded 28 per cent of albans and 8 per cent of fluavils. The residue insoluble in alcohol was dissolved in chloroform, filtered, and poured into alcohol, by which means the gutta separated at once as a spongy mass; the mother liquor slowly deposited the albanans as a crystalline mass on standing; these were purified by repeating the process. The gutta itself was purified by repeatedly dissolving in chloroform and precipitating with alcohol.

The fluavils were separated by treatment with 80 per cent alcohol into $\alpha$-guinfluavil and $\beta$-guinfluavil, both yellow amorphous substances. Alcoholic potash hydrolyzed each into cinnamic acid and a distinct crystalline resinol.

The albans were separated by treatment with warm 96 per cent alcohol into three distinct crystalline substances—viz., $\alpha$, $\beta$, and $\gamma$ guinalban. The two latter were hydrolyzed by alcoholic potash, yielding in each case cinnamic acid and a distinct crystalline resinol. Of the albanan (guinalbanan) only 0.7 per cent was obtained, but again in crystalline form, and with constant melting-point. Exposure to light, however, resulted in a lowering of the melting-point, with simultaneous increase in the solubility in water.

The gutta, which forms the bulk of the drug, was obtained by deposition from its hot ethereal solution as minute curved crystalline needles, which, however, gradually agglomerated into a solid mass. When pure it is quite white, and remains so when kept under ether or alcohol, but when dried and exposed to the air it assumes a reddish color. It is not attacked by alcoholic potash.

The albans from Sumatra gutta-percha are also cry-

* Abstract of papers published in the Archiv. d. Pharm., 243, 114.

stalline, and yield by hydrolysis with alcoholic potash in each case cinnamic acid and a characteristic crystalline resinol. The albans have been designated $\alpha$, $\beta$, and $\gamma$-sumalban, and the resinols $\alpha$, $\beta$, and $\gamma$-sumalbaresinols. All the albans examined showed a strong resemblance in the qualitative reactions to phytosterin.

The authors have also extracted from caoutchouc resinous bodies resembling the albans of gutta-percha, to which they propose to apply the same terminology; they did not, however, yield cinnamic acid by hydrolysis.

## ENGINEERING NOTES.

**No more significant change** is taking place in American agriculture than the extent to which different kinds of motive power are taking the place of men and animals. The use of the traction engine and automobile in the place of the horse on the country roads, the employment of gasoline, steam, wind, and electric power to operate mowers, threshers, plows, feed cutters, corn huskers, and dairy machinery are illustrations of epoch-making changes that are now going on on every modern American farm. On one ranch in California there is $60,000 worth of farm machinery operated by some other power than animals or man. For want of proper information these changes are involving farmers in serious mistakes and large losses. They buy motors not suited to their requirements or which they do not know how to operate. They buy machinery not adapted to their condition and cause its rapid destruction by not knowing how to care for it.

**The hardness and toughness** of a rock which is going to be used on a road are, as everyone knows, important properties, but the property which causes this rock under the influence of traffic to bind or cement together so as to form a smooth, even, impervious shell on the surface of a road is even more important. When the work of the Road Material Laboratory of the U. S. Department of Agriculture first began the importance of this quality had hardly been recognized, and absolutely nothing was known as to the reason why one rock should possess this property to a very high degree and another of perhaps identically the same name and species should be entirely lacking in it. The closest investigation has been given to this subject and to the collection of all possible data and information, not only from the theoretical and laboratory standpoint, but also from a practical point of view. It is safe to say that its satisfactory solution has been accomplished. A bulletin on "The Cementing Value of Road Materials" has just been published, and the publication of more work in the same line will follow shortly.

**A power boat** of huge dimensions has recently been constructed at Nishni Novgorod, Russia, for the transportation of oil from Rebinsk on the Volga to St. Petersburg, a distance of 700 miles. The vessel measures 245 feet in length over all, 32 feet beam, and about 1,100 tons displacement. The motive power is supplied by three 120-horse-power Diesel vertical petroleum motors, each connected to a large dynamo. The electrical energy thus developed drives three electric motors in the stern, each of which is coupled to a propeller. The amount of oil consumed on one round trip is estimated at 3,600 gallons, but storage accommodation for 12,000 gallons is provided in the bow and stern. A second boat is now being built, but is of somewhat different design. In this vessel power will be developed by two sets of Diesel motors, each of 180 effective horse-power. The engines and propeller shafts will be supplied with clutches, so that when the boat is to run a long distance without stopping, the motors can be connected directly to the propeller shafts.

**Great interest** is being evinced in England in the trials that are being carried out with a new type of submarine. This craft is of small dimensions, and can easily be stowed on the deck of a battleship, and lowered to or raised from the water whenever desired, or if necessary can be transported on a railroad car from one point to another. The submarine measures 34 feet in length by 6 feet 9 inches diameter, and has a displacement when fully submerged of 17 tons. It is propelled solely by electricity, the use of gasoline being entirely discarded. When submerged, the boat has a speed of eight miles an hour. In view of the fact that the submarine under ordinary conditions will be carried on board a battleship or cruiser ready for instant consignment to the water, the fact that electric motive power necessarily gives a smaller radius than a gasoline-propelled boat will not militate against its utility or efficiency, but will render it safer to operate, and this advantage, it is claimed, will compensate the disadvantage of limited range of action. The boat carries two torpedo tubes and a crew of three. At the submersion trials the boat remained under water for more than three hours without the crew experiencing any atmospherical inconvenience. When the storage batteries are fully charged, the submarine has a radius of forty miles.

**An accurate knowledge of** the percentage of solid impurities contained in blast-furnace gases is of the highest importance, with a view to their use for engines. Gases from coke blast furnaces charged with friable ores will contain from 4 to 6 grammes dust to the cubic meter, and 2 to 4 grammes in the case of solid ores, while 1.5 to 2.5 grammes of dust are contained in gases from charcoal blast furnaces. Such gas should be cleaned to within 0.1 to 0.01 gramme of dust to the cubic meter, before being used for the operation of motors. To determine the percentage of dust, the gas is mostly filtered through a weighed layer of cotton, using a gas meter. This method, however, shows the drawback that the cotton is hygroscopic and the gas meter expensive, while a preparation of satisfactory filters is by no means easy. Mr. E. D. Hubendick, according to a report in the Chemiker Zeitung, therefore suggests another apparatus consisting of two conical sheet-metal reservoirs having flat edges underneath and necks susceptible of being corked. Two India-rubber rings are fitted between the edges, and between these a disk of filter paper, after which the two edges are screwed together. If the gas be sucked through the apparatus from above downward, any impurities will remain in the paper. The measuring and suction apparatus consists of two divided bottles of at least 5 liters capacity, containing a thermometer. By means of India-rubber tubings, connecting this apparatus to the filter press, it is possible each time to draw five liters through the filter apparatus, by alternately lowering and lifting the bottle, so as to be able to filter about 200 liters gas in 30 to 60 minutes. After any corrections for pressure and heat have been made in the gas volume, the filter paper is removed from the apparatus, and after it has been dried, its weight will allow the dust to be determined.

## SELECTED FORMULÆ.

**Worcestershire Sauce.**—

| | |
|---|---|
| Allspice | 7.0 |
| Cloves | 3.5 |
| Black pepper | 3.5 |
| Ginger | 3.5 |
| Curry powder | 30.0 |
| Spanish pepper (paprika) | 3.5 |
| Mustard | 60.0 |
| Shallots, cut up | 60.0 |
| Salt | 60.0 |
| Sugar | 40.0 |
| Tamarinds (the fruits) | 120.0 |
| Sherry | 570.0 |
| Wine vinegar | 1,140.0 |

Boil the freshly reduced spices gently for an hour in the vinegar, adding a little more of the latter than is lost by evaporation (this can easily be recognized by the changed volume). After that add the sherry, and if desired a little caramel for coloring. Coloring with caramel is not absolutely necessary; only if the sauce should turn out a little too light (pale) it may be advisable. Copper vessels faultlessly tinned inside, or enameled vessels may be employed.

Let the whole stand for a week, strain it, and fill in bottles. Worcestershire sauce is never quite clear; straining to remove the coarser particles is all that is necessary.—Neueste Erfahrungen und Erfindungen.

**Flower Manures.**—1. Salt peter 5 parts, cooking salt 10 parts, bitter salt 5 parts, magnesia 1 part, sodium phosphate 2 parts. Mix and fill in bottles. Dissolve a teaspoonful in 1 liter (about a quart) of hot water, and water the flower pots with it each day.

2. Ammonium nitrate 40 parts, ammonium phosphate 50 parts, potassium nitrate 90 parts. Two grammes of this fertilizer suffice for a medium-sized flower pot.

3. Ammonium sulphate 10 parts, sodium chloride 10 parts, potassium nitrate 5 parts, magnesium sulphate 5 parts, magnesium carbonate 1 part, sodium phosphate 20 parts, 1 teaspoonful to 1 liter of water.

4. Ammonium nitrate 40 parts, ammonium phosphate 20 parts, potassium nitrate 25 parts, ammonium chloride 5 parts, calcium sulphate 6 parts, ferrous sulphate 4 parts. Make doses of 2 grammes each, which are dissolved each in 1 liter of water, and use the solution for watering the potted plants.

5. Potash niter 20 parts, potassium phosphate 25 parts, ammonium nitrate 35 parts, ammonium sulphate 10 parts. Through this mixture a luxurious foliage is secured. If it is desired to act more on the flowering, the ammonium nitrate must be omitted.

6. Ammonium sulphate 30 parts, sodium chloride 30 parts, potash niter 15 parts, magnesium sulphate 15 parts, magnesium phosphate 4 parts, sodium phosphate 6 parts. Dissolve 1 gramme in 1 liter of water, and apply three times per day.

7. Calcium nitrate 71 parts, potassium chlorate 15 parts, magnesium sulphate 12.5 parts, potassium phosphate 13.3 parts, freshly precipitated ferric phosphate 3.2 parts. A solution of 1 gramme of this mixture is applied, alternating with water, to the plants. After using a certain quantity, pour on only water.

8. Ammonium phosphate 300 parts, sodium nitrate 250 parts, potassium nitrate 250 parts, and ammonium sulphate 200 parts, are mixed together. To every liter of water dissolve 2 grammes of the mixture, and water the potted plants once a week with this solution.

9. Potash niter 20 parts, calcium carbonate 20 parts, sodium chlorate 20 parts, calcium phosphate 20 parts, sodium silicate 14 parts, ferrous sulphate 1.5 parts. Dissolve 1 gramme of the mixture in 1 liter of water.

10. Calcium nitrate 100 parts, potassium chlorate 30 parts, potassium phosphate 30 parts, magnesium sulphate 20 parts, ferrous sulphate 0.1 part. Dissolve 2 grammes of the solution in 1 liter of water.

11. Dissolve potash niter 100 parts, ammonium phosphate 100 parts, and phosphoric acid 2.5 parts in 1,000 parts of ordinary syrup. For 1 liter of water add at most 10 cubic centimeters, and apply this solution, alternating with ordinary water. For Cactaceæ, Crassulaceæ, and similar plants, which do not directly assimilate organic substances, distilled water should be used instead of syrup. Chlorotic plants should be coated with dilute solution of iron, or else iron should be admixed to the soil, whereupon they will become green again. The iron is absorbed in the form of ferric chloride or ferrous sulphate.—Pharmaceutische Zeitung, Berlin.

## ELECTRICAL NOTES.

**Printing telegraphs** require a high degree of fine mechanical skill for their construction and maintenance. Skill of that kind does not exist in new countries, and it is only recently that one or two printing telegraphs have reached the stage at which it pays telegraph administrations in these new countries to import and cultivate such skill. These big new countries are essentially rough and ready, and for the rough-and-ready stage of civilization nothing can beat the Morse key and sounder. Even the United States is only now emerging from this rough-and-ready stage of national existence, at any rate so far as telegraphy is concerned, and it is the opinion of those who are in a position to judge, that there will be a great development of printing telegraphy in the United States within the next ten years. The conditions are at last ripe for the change. Saving of wire owing to the great distances in America is important, and saving of labor owing to the high wages is a factor not to be neglected.

**The observatory** of the Paris Bureau des Longitudes has been looking for a process that might allow the existing telephone systems to be used for the accurate transmission of time. A similar transmission can evidently be effected either by sending a signal at a moment arranged for beforehand or by numbering the strokes of a clock. The above processes, however, will not insure any high accuracy, so that other means had to be devised. As pointed out by Mr. E. Guyou in a recent note presented to the French Academy of Sciences, a satisfactory process was eventually found in transmitting the sound of the strokes of the clock directly by means of a special microphone introduced into the casing of the instrument, without the use of any electrical contact liable to interfere with the motion of the clock. All the sender has to do is to number two or three strokes, when the operator at the receiving station continues counting mentally. The method has been tried with excellent results, both on the Parisian and the general French telephone systems, time being transmitted successfully to the Chronometer Bureau of the Navy and to several makers of precision watches. On May 25 the torpedo destroyer "L'Escopette" was able to regulate her chronometers from the clock of the Montsouris Observatory, and two days afterward some naval officers could regulate their watches within 0.15 second. This method of transmitting time will doubtless prove useful both to the watchmaking industry and to such scientific institutions as require an accurate knowledge of time, at any place where a connection to the telephone system can be had. Both mercantile and war ports could dispense with any astronomical observatories intended to regulate the chronometers of sailing vessels. The same process could, moreover, be utilized for determining longitudes, as the operators on both stations would be in a position to record the time on the same clock. The observatory of the Bureau des Longitudes, which is at present equipped with four good clocks, has organized a daily comparison service analogous to the one used on sea-going vessels, to derive from a set of chronometers the Paris time, which is necessary to determine longitudes. The average Paris time can accordingly be obtained now from any telephone post, with the same precision as in observatories fitted with four good clocks that are regulated astronomically, whenever weather permits, and checked with each other in the intervals between observations.

**Among the new electric railroads** which are now in operation in Europe may be mentioned the Amsterdam-Haarlem line. This road is laid in double track and it has been recently opened for traffic. It runs between the city of Amsterdam and the town of Haarlem, continuing past the latter point to the shore of the North Sea where it terminates at the seaside resort of Zandvoort. For most of the way the new electric road has been built parallel to the steam railroad. A better system of traffic was needed for some time past between Amsterdam and Haarlem, as the latter may be said to form a suburb of Amsterdam, although it lies about 10 miles off. Frequent trains were found necessary to take care of the suburban traffic and accordingly the electric system was adopted. The line is narrow gage, which allows it to take in the existing lines at Haarlem. The latter have some 9 miles total length. At Amsterdam where the tracks are standard gage, an extra rail has been laid alongside so as to accommodate the new cars. The track thus formed runs for a mile or so within the city. Considerable difficulty was experienced in laying the main line owing to the fact that it runs for most of the way along the public route and this road follows one of the large canals. On the side of the canal space had to be provided for the electric line which runs on either side of the route, by an additional fill. The latter is retained on the side of the canal by a series of piles and a timber framework which upholds the embankment all along the route. At the other side of the road is a deep ditch which had to be treated in the same way for the second track. The line crosses two canals at Halfweg, about the middle point of its course. A bridge having six 50-foot trusses is constructed here, and a second bridge of similar construction takes the line into Haarlem. From this point the road traverses the dunes as far as the North Sea. Vignole rails of 35 kilos per meter are used for the track. The ties are of Norway creosoted pine. The overhead trolley line is held above each track by strong trellis-work poles and brackets. The rolling stock consists of 34 cars, built at Brussels, of 40-foot length and placed on two bogies. The cars have end platforms and a central passage. Current is taken from the overhead line by an arched trolley. A generating station has

been erected at Halfweg to supply the current. It is built entirely upon piles. The station has six Lancashire boilers and three engines. The latter are triple-expansion, and give 450 horse-power each. Westinghouse dynamos are coupled to the engines, giving 540 to 570 volts direct current for the line. The total length of the electric road is some 12 miles, not counting the portions within the cities.

## SCIENCE NOTES.

**By nature** the "grapevine" is evidently a great rambler. Pliny states that because the vines of Italy climbed to the tops of the highest poplars the grape gatherers in vintage time stipulated with the master that in case their feet should slip and their necks be broken he was to order and pay for the funeral pyre and tomb.

**Nut-growing** in the United States would be a much more profitable industry were it not for the insects which inhabit the kernels, rendering them unfit for food. This is especially true of the chestnut and chinquapin and to a lesser extent of pecan, hickory, and hazel nuts; while others, which include butternuts, walnuts, and almonds, suffer little or no injury from this source. Considerable diminution in the yield of many forms of nuts is also caused by the inroads of insect larvæ in the growing husks. Examples of the first class are the chestnut "worms" or weevils; of the second, the husk-worms and walnut curculio. The present paper will be restricted to a consideration of the weevils.

The chestnut crop suffers the greatest loss, and the chief depredators are the grub-like "worms" or larvæ with which everyone is too distressingly familiar. These larvæ develop with the nuts, so that those which first attain maturity are ready to leave and enter the ground nearly as soon as the nuts are gathered; others remain in the nuts some weeks later; so it frequently happens that when nuts are packed for shipment in bags or barrels, some nuts which were apparently sound when shipped are found, on reaching their destination, with one or more holes in their shells, while the repulsive grubs crawl about at the bottom of the receptacle. How to cope with these weevils has long been a most vexatious problem.

**In its strictest sense** the word "agriculture" refers to the cultivation of the soil for the purpose of increasing the growth and yield of valuable plants. In its broadest sense, agriculture is the oldest and most fundamental of all the arts of civilization. The first steps in agriculture must certainly have been the simple stirring of the soil in search of edible roots, followed by the observation that plants grew better and yielded more abundantly in such stirred soil. The stimulating effect of excrement and decayed organic matter must also have been very early observed and practised. In the early stages of agriculture the cultivation of special food plants in patches or fields on soils most conveniently located and easily cultivated and giving the best results was a simple and natural step even for the most primitive man. In accordance with the practice of all plant-eating animals, man selected for his use the individual plants which he liked the best and which produced valuable returns for him with the least labor on his part. Thus, there gradually came into existence selected and cultivated strains of plants better adapted than their wild progenitors to the uses of man. The changes or variations were slight at first, but we know from experience how greatly wild plants may be modified and improved by cultivation and selection. Within a few years such treatment is often sufficient to make them almost unrecognizable. It is thus easy to realize how great the changes must be that are produced by centuries and centuries of such treatment under a great variety of conditions. The process has thus been essentially a natural selection, man's like or dislike being the critical factor. Darwin was the first naturalist to comprehend this fact fully, and it was the study of variation under domestication and the history of domesticated plants and animals that enabled him to comprehend the great influence of continued selection in the modification and origin of species. Up to the time of Darwin, about the middle of the nineteenth century, the dogma of the constancy of species was almost universally believed. Species were held to be special creations, a theory which effectually answered all questions as to origin and stifled investigation. But regardless of any theoretical notions held by philosophers of that time, agriculturists realized the great importance of selection and crossing in the improvement and modification of animal species. Darwin quotes from Youatt, who, he says, was probably better acquainted with the works of agriculturists than almost any other individual. Youatt speaks of selection as "that which enables the agriculturist not only to modify the character of his flock, but to change it altogether. It is the magician's wand, by means of which he may summon into life whatever form and mold he pleases." He, of course, refers to the art of animal breeding, which is of very ancient origin and practice and differed from the practice of the early plant breeders in that hybridization and crossing, as well as careful selection, were followed by the animal breeders. The sexuality of plants, however, was not known until comparatively recent times, and crossing and hybridization were not, therefore, consciously used in the early development of our agricultural plants. The first scientific proof of the sexuality of plants was furnished by Camerarius in 1691. It was not until twenty years later, however, that the first recognized plant hybrid was made.

JUST PUBLISHED

**American Tool Making and Interchangeable Manufacturing**

*By* JOSEPH V. WOODWORTH

THIS book is a complete practical treatise on the Art of American Tool Making and System of Interchangeable Manufacturing as carried on to-day in the United States. In it are described and illustrated all of the different types and classes of small Tools, Fixtures, Devices and Special Appliances which are, or should be, in general use in all machine manufacturing and metal working establishments where economy, capacity and interchangeability in the production of machined metal parts are imperative.

All of the tools, fixtures and devices illustrated and described have been, or are, used for the actual production of work, such as parts of Drill Presses, Lathes, Patented Machinery, Typewriters, Electrical Apparatus, Mechanical Appliances, Brass Goods, Composition Parts, Mould Products, Sheet Metal Articles, Drop Forging, Jewelry, Watches, Metals, Coins, etc.

The treatment of each tool described and illustrated is such as to enable any Practical Man to Design, Construct and Use Special Tools, Dies and Fixtures, for the Rapid and Accurate Production of Metal Parts Interchangeably.

To the Machinist, Tool Maker, Designer, Die Maker, Superintendent, Manager and Shop Proprietor this book shows the 20th Century Manufacturing Methods and Assists in Reducing the Expense and Increasing the Output and the Income. A book on the System of Interchangeable Manufacturing—The System that has Won for the United States the Industrial Supremacy of the World.

**535 Pages Bound in Cloth 600 Illustrations**

**PRICE $4.00**

MUNN & CO., Publishers
SCIENTIFIC AMERICAN OFFICE
361 BROADWAY - - NEW YORK

TWENTY-THIRD EDITION

**EXPERIMENTAL SCIENCE**

*By GEORGE M. HOPKINS*

*Revised and Greatly Enlarged. 2 Octavo Volumes. 1,100 Pages. 900 Illustrations. Cloth Bound, Postpaid, $5.00. Half Morocco, Postpaid, $7.00. Or Volumes Sold Separately: Cloth, $3.00 per Volume. Half Morocco, $4.00 per Volume.*

EXPERIMENTAL SCIENCE is so well known to many of our readers that it is hardly necessary now to give a description of this work. Mr. Hopkins decided some months ago that it would be necessary to prepare a new edition of this work in order that the many wonderful discoveries of modern times might be fully described in its pages. Since the last edition was published, wonderful developments in wireless telegraphy, for example, have been made. It was necessary therefore that a good deal of new matter should be added to the work in order to make it thoroughly up-to-date, and with this object in view some 200 pages have been added. On account of the increased size of the work, it has been necessary to divide it into two volumes handsomely bound in buckram.

THE
Scientific American Supplement.
PUBLISHED WEEKLY.
Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

## TABLE OF CONTENTS.



**Home Mechanics for Amateurs**


This book has achieved an unparalleled success in one week, and a Special Edition of 4,000 copies has been ordered. It is by far the largest and best book on the subject ever offered at such a low price. It tells how to make things the right way—the "only" way—at small expense It will prove of value to you—much more than you realize. Do things with your hands. Send for a circular giving contents—the circulars cost only a cent—the book $1.50 postpaid. If the book could meet you face to face you would be the first to purchase. The first large edition is almost gone. Order to-day.

**370 Pages 326 Engravings Price $1.50**

LATEST EDITION
.... OF ...
**Supplement Catalogue**
JUST OUT!

Write for it. It costs nothing.

The new Catalogue contains 65 pages and gives a list of over 17,000 articles.

If there is any scientific, mechanical or engineering subject on which you wish special information, you will find in this Catalogue some papers in which it is thoroughly discussed by a competent authority.

SCIENTIFIC AMERICAN SUPPLEMENT papers for the most part have been written by the world's most eminent engineers and scientists. They contain information that is not always accessible in books.

MUNN & COMPANY, PUBLISHERS
361 BROADWAY NEW YORK CITY

.905.

ment.

.

s in any
ollars a

rom the
Price,

an like-
yearly.
or $3.50

MERICAN
ENT, one

ts, and

N. Y.



CS

in one
ion of
ed. It
t book
at such
make
only"
t will
more
s with
rcular
rs cost
post-
et you
e first
arge

$1.50

e